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EVALUATION OF 30 KW AND 2.5 KW GENERATORS USED ON SERVPAC ARS A--ETC(U)  
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EVALUATION OF 30 KW AND 2.5 KW  
GENERATORS USED ON SERVPAC  
ARS AND ATF CLASS SHIPS

November 1974

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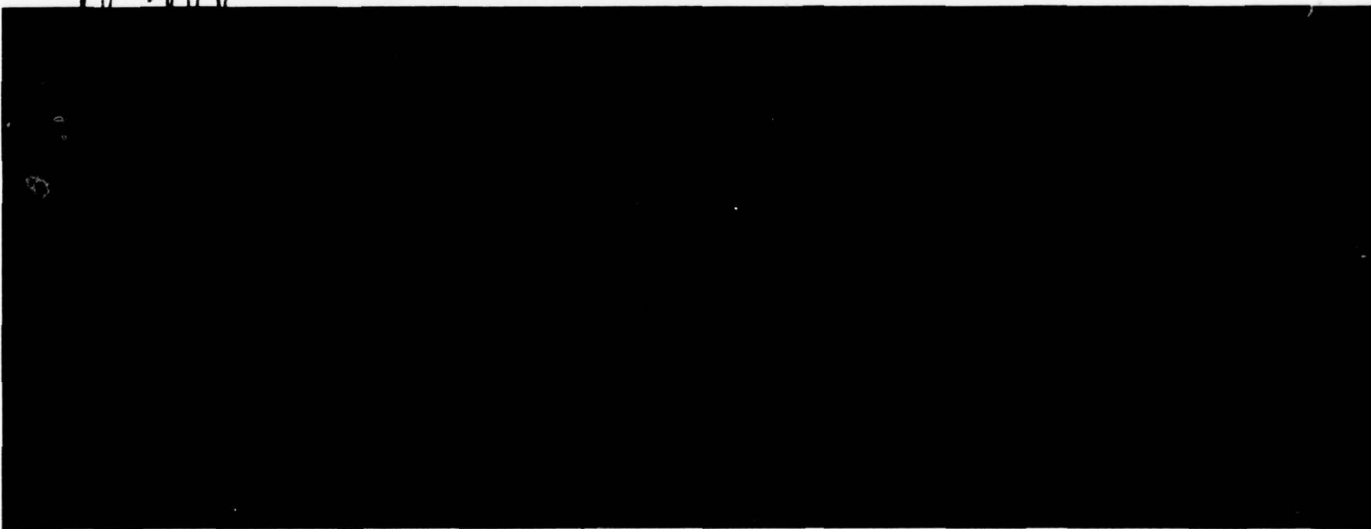
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E. E. Bethke  
R. N. S. Ho

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HONOLULU SUPPORT OFFICE  
245 Fort Street, Suite 211  
Honolulu, Hawaii 96801

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## ABSTRACT

An investigation of problems associated with two types of generators used in Navy ARS and ATF class ships is described. Causes of and recommended corrective actions are discussed for failures being experienced by the 30 kW motor generator set, and inadequacies in the emergency communication system utilizing the 2.5 kW diesel generator set.

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## SUMMARY

The 30 kW motor generator (MG) used in ARS and ATF class ships of the Service Force, Pacific has experienced many types of failure, to an extent suggesting a possible reliability problem. On the same ship types, the emergency communication system utilizing the 2.5 kW diesel generator has proven to be inadequately designed.

ARINC Research Corporation was contracted to investigate these problems, determine the causes, and recommend corrective actions. The major conclusions drawn from this study are summarized below.

- a. The failure problems experienced by the 30 kW MG set appear to have been brought under control by action already taken by the Navy. These failures were centered in the control circuitry of the MG set. Steps taken to correct the failure conditions primarily involved improvement of the ventilation in the control panel, and the correction of errors made in the installation of the MG sets.
- b. The improved ventilation compensates for an inherent problem in the control circuitry. Should the Navy desire to correct the basic fault, the necessary changes to the circuitry (primarily part substitutions) are detailed in this report.
- c. This study confirmed that the emergency communication system used on the ARS and ATF class ships is inadequately designed. A design providing maximum flexibility of emergency-power utilization is recommended herein.

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# 1

## INTRODUCTION

ARS and ATF class ships of the Service Force, Pacific have experienced problems relating to two types of electrical power sources: the 30 kW motor generator set and the 2.5 kW diesel generator set. In the 30 kW set, many different types of failures have been reported. Emergency communication systems powered by the 2.5 kW set have been found to be of generally inadequate design.

Under Contract N00604-74-C-0234, ARINC Research Corporation was directed to investigate these problems and recommend corrective procedures. Tasks necessary to accomplish these objectives are listed below.

### a. 30 kW Motor Generator Set

- 1) Evaluate material history and casualty report (CASREPT) data on 30 kW sets used on all ARS and ATF ships of SERVPAC.
- 2) Analyze failures to determine critical subsystems or components causing or contributing to operational difficulties.
- 3) Perform circuit and/or system analyses of critical subsystems to determine the most likely cause(s) of encountered problems.
- 4) Provide recommendations for improving the reliability of the 30 kW set.

### b. 2.5 kW Emergency Diesel Generator

- 1) Evaluate the present emergency communication configuration on SERVPAC ARS and ATF ships.
- 2) Determine emergency communication requirements.
- 3) Design a system configuration, utilizing the 2.5 kW diesel generator set, that will provide improved emergency communication capability.

Conclusions and recommendations resulting from this effort are given in Section 2. Study details, including the technical approach and investigation results, are presented in Section 3 for the 30 kW motor generator set, and in Section 4 for the 2.5 kW diesel generator and associated emergency communications system. Analyses and documentation supporting the investigation are presented in the appendixes.

## CONCLUSIONS AND RECOMMENDATIONS

Several important conclusions resulted from this study, and are summarized below together with accompanying recommendations where appropriate.

### 2.1 30 KW MOTOR GENERATOR SET

#### 2.1.1 Failure Types

Reported problems with the 30 kW MG set aboard ARS and ATF ships of SERVPAC fall within two failure categories: normal deterioration and control circuitry malfunction. Within these categories:

- a. All reported failures of the normal deterioration type were unique — there was no trend or pattern to their occurrence. Such failures were typically worn bearings, scored commutators, worn brushes, defective meters, etc.
- b. Problems traceable to control circuit malfunctions had commonality among ships having similar installations and equipment characteristics of the 30 kW MG set.

#### 2.1.2 Configuration Study

To accurately correlate problems with equipment installations and characteristics, a configuration study was conducted to determine the present 30 kW MG set equipment complements aboard ARS and ATF ships of SERVPAC. Five different equipment configurations are utilized, encompassing fifty 30 kW MG sets aboard 21 ships. Of the fifty 30 kW MG sets, 16 have been reported as experiencing circuitry problems and/or failures. Of these 16 sets, only one (aboard USS TAKELMA) continues to exhibit control circuitry problems. The ships on which the other 15 sets are located implemented component changes and/or provided needed ventilation in MG set control panel spaces. No recurrence of the problems has been reported by these ships.

#### 2.1.3 Installation-Related Problems

In this study, ARINC Research visited 75% of all ARS and ATF type ships of SERVPAC. Observation of the 30 kW MG set installations led to the following conclusions and recommendations.

- a. In many instances, the MG sets are inadequately installed relative to ventilation, heat sinking, physical wiring, and location of the control panel. In some cases the wiring to the control panel covered a large portion of the bottom ventilation grating of the control panel cabinet. These wires impede the flow of air into the cabinet, allowing component operating temperatures

to rise to a level where circuit functions may be altered to the extent that component failures can occur. For MG sets with heat-related problems, the clearing of this wiring is highly recommended as the first step to improving the situation.

- b. Aside from this wiring problem, two ships had unique installations that may be a potential cause of future problems:

- 1) In GRASP, a control cabinet for one MG set is located directly on top of the control cabinet of another set. The intended natural ventilation of these cabinets is defeated by the lack of an air supply to the lower unit and the restricted intake to the bottom of the upper unit. The sides are also blocked off by adjacent panel supports. Excess cable wire lengths between the entrance bushings, and terminal boards block off the air inlet screen. An improved relocation is recommended to enhance ventilation within these cabinets.

A large portion of GRASP's electronic load was also found to be connected to one phase of the three-phase generator. This condition creates a highly unbalanced load. A redistribution of loads to the three-phase power source is recommended in conjunction with emergency power distribution modifications to be discussed (Section 2.2). As previously noted, this recommendation is based on shipboard observation, not on a comprehensive analysis. Therefore the implementation of this recommendation will not solve all of the problems associated with GRASP's 30 kW MG set; however, it will improve the overall reliability of the generator winding.

- 2) RECLAIMER's control panel was found to be installed directly above the exhaust of its motor generator. The exhaust is presently directed into one-half of the control panel cabinet, causing inside temperatures to be very high. The installation of a heat deflector to direct the exhaust away from the control panel's lower ventilation grating is recommended.

#### 2.1.4 Circuit Analysis

Detailed testing and analysis of a failed overspeed-circuit board revealed a deficiency in the overspeed circuit of a 30 kW MG set identified by TM NavShips 0962-046-0010 and manufactured by Electronic Specialty Corp. The overspeed threshold was found to decrease with increasing temperature, thus causing premature actuation of the overspeed circuit. Circuit component modifications as given in Appendix C are recommended for all MG sets that have heat-related problems and are of the type identified by the subject technical manual.

#### 2.1.5 Magnetic Pick-up Problem

Three basic configurations of the 30 kW MG set that utilize magnetic probe pick-ups were found to exhibit problems relating to that element. These configurations are identified by NavShips 0962-046-0010, 0961-038-4010, and 0961-040-4010. False actuation of the overspeed circuit has been caused by noise on the overspeed magnetic probe cable. These noise problems result from incorrect shielding and/or grounding of the magnetic pick-up cables. The approach to correcting this condition is given in Appendix B.

#### 2.1.6 Safety Hazard

A 30 kW MG set aboard ABNAKI has a potential equipment-safety hazard. A configuration B MG unit has a configuration A control cabinet. Without a modification to the MG unit, these devices are not compatible and would leave the MG without overspeed protection. The recommended corrective action is given in Section 4.2.

#### 2.1.7 Logistic Support

For the MG set, logistic support for high-failure-rate components and their associated printed circuit boards appears marginal to nonexistent, based upon comments from ship personnel. The long-lead times experienced as the general rule (frequently as long as 60 days) indicate exhaustion of any spare parts that may have been in the Navy supply system when the 30 kW MG sets were new. A rotating pool of all PC boards used in these equipments, and a depot level maintenance program to support it, is recommended. This would compensate for inadequacies found in personnel allowances for ARS/ATF type ships, which necessitates dependence on outside help in this area. If a rotating pool of PC boards is not possible, applicable spare boards should as a minimum be stocked aboard ship.

### 2.2 2.5 KW DIESEL GENERATOR SET

Redesign of the emergency communication system built around the 2.5 kW emergency diesel generator was performed by ARINC Research in accordance with COMSERVPAC requirements. A recommended design providing maximum equipment-selection flexibility is defined in this report. This design involves a 3-pole, double-throw manual bus transfer (MBT) switch. A table of equipment power requirements to be used in conjunction with a meter to measure generator loading is also recommended. Depending on the emergency situation, any equipment or set of equipments connected through the MBT may be used with the emergency generator. The only restriction is that the power requirement does not exceed the emergency generator's capacity. By observing the wattmeter, or ammeter, this condition can be controlled.

The problem involved with the 2.5-kW emergency diesel generator was found to be different for every ship visited in this study. Therefore, to implement effectively the design recommended in this report, ARINC Research recommends that implementation plans and procedures be prepared individually for each ARS and ATF ship. The plans for each ship should identify all applicable equipment on board; equipment to be purchased for installation; and equipment cost, manufacturer, and model.

While individual plans are necessary, their specified equipments and installation procedures should be as uniform as possible in the interests of minimizing the costs of logistic support, installation, and documentation.



## RELIABILITY INVESTIGATION, 30 KW MOTOR GENERATOR SET

### 3.1 STUDY APPROACH AND CONDITIONS

The initial step in addressing the problem of recurring failures in the 30 kW motor generator was to evaluate data on failures and other incidents recorded for all MG set configurations. Types of data required for this evaluation included material history reports, CASREPTs, repair-activity condition reports, and detailed information on circuit failures. The first two data types were readily available through existing Navy publications and discussions with ship personnel. The latter two data types were of limited availability.

To augment the available information, ARINC Research conducted ship visits and performed failure analyses on all available failed circuit boards of the MG sets. Visited were the following 16 of the 21 ARS and ATF class ships of SERVAPAC:

USS GRAPPLE (ARS-7)	USS TAWASA (ATF-92)
USS DELIVER (ARS-23)	USS ABNAKI (ATF-96)
USS GRASP (ARS-24)	USS CHOWANOC (ATF-100)
USS BOLSTER (ARS-38)	USS COCOPA (ATF-101)
USS CONSERVER (ARS-39)	USS HITCHITI (ATF-103)
USS RECLAIMER (ARS-42)	USS QUAPAW (ATF-110)
USS CREE (ATF-84)	USS TAKELMA (ATF-113)
USS MATACO (ATF-86)	USS TAWAKONI (ATF-114)

Unavailable were the USS SAFEGUARD (ARS-25), MOCTOBI (ATF-105), MOLALA (ATF-106), APACHE (ATF-67), and UTE (ATF-76); the latter two were scheduled for decommissioning this year.

In these visits, ARINC Research conducted equipment checks and held discussions with ship personnel concerning the MG set. Failed circuit boards were requested of the ships through COMSERVPAC; however, during the period January to August 1974 only three circuit boards were obtained — two from TAWAKONI and one from CREE. Detailed failure circuit analyses were performed on these boards.

The insufficiency of detailed failure reports, and the lack of failure occurrences during the contract period, necessitated that ARINC Research reconstruct failure modes based on available data and then surmise possible causes of failure.

Due to the variety of manufacturers and configurations of the 30 kW MG set, and differences in installation and operating environments, the problems investigated were found to be unique for every ship and motor generator. Thus it was considered impracticable to recommend general modifications applicable to all MG sets. This report therefore presents recommendations applicable to each ship, or to groups of ships having similar MG set configurations.



### 3.2 FAILURE HISTORY

Reported failures in the MG set were found to be of two general types:

- a. Those due to normal deterioration, such as worn bearings, worn brushes, scored commutators, etc.; and
- b. Those associated with failed subsystems, components, circuit boards, etc.

COMSERVPAC and ARINC Research personnel agreed that it would be more cost effective to seek improvements in the reliability of the MG set by solving those problems not associated with normal deterioration. The next step in the investigation was to list all reported problems relating to critical subsystems, components, and circuit boards, and associate them with particular ships. Data were obtained from two Maintenance Data Collection System (MDCS) reports, Detailed Record of Completed and Outstanding Repair/Alterations Action — November 1971 to October 1973; and Detailed Record of Material History of 30 KW MG Sets — November 1971 to October 1973; from CASREPTs; and through discussions with personnel of COMSERVPAC, COMSERVGRU FIVE, the ships, and the Design Division of Pearl Harbor Naval Shipyard.

Many of the failed items (meters, relays, coils, etc.) seemed to be of insufficient quality. Further, most failures were found to be associated with the motor generator control circuitry — the speed regulator, overspeed protection circuit, and voltage regulator. These failures had commonality among many ships, and were consequently the ones on which most of this study effort was spent.

Table 1 summarizes all reported failures and operational problems on the 30 kW motor generator set for the ARS and ATF class ships. As shown in the table, of the 21 ARS and ATF ships:

- a. One (BOLSTER) does not have 30 kW MG sets installed;
- b. Nine have reported no major problems with the MG set other than normal wear/deterioration type; and
- c. Eleven have reported problems associated with the control circuits of the MG set.

It is conceivable that many relevant problems were never reported, and many of the reported problems occurred more often than the records show. Therefore the failure summary of Table 1 should not be interpreted as being complete — it represents only reported information from the referenced data sources.

### 3.3 CONFIGURATION STUDY

A configuration study was next conducted to identify the types of motor generator sets and control panels installed aboard each ship. This distribution is summarized in matrix form in Table 2. The table shows, for five basic configurations of the 30 kW motor generator set, the number of sets aboard each ship. (Also indicated parenthetically, in connection with a discussion in Section 3.4, is the extent to which these sets need installation improvements.)

TABLE 1. FAILURE/PROBLEM SUMMARY FOR  
30 KW MOTOR GENERATOR (Sheet 1 of 2)

Ship	Control Circuit Failure/ Problem	Other Failures/ Problems
GRAPPLE (ARS-7)	(No major problems reported)	
DELIVER (ARS-23)	(No major problems reported)	
GRASP (ARS-24)	Set experienced intermittent shutdown, but could be started again immediately.	
SAFEGUARD (ARS-25)	Premature actuation of over-speed circuit.	
BOLSTER (ARS-38)	(30 kW MG sets not installed)	
CONSERVER (ARS-39)	Intermittent shutdowns by the overspeed circuit. Problem was circumvented by setting frequency to about 58.5 Hz vice 60 Hz.	
RECLAIMER (ARS-42)	(No major problems reported)	
APACHE (ATF-67)	(No major problems reported)	
UTE (ATF-76)	(No major problems reported)	
CREE (ATF-84)	Overspeed circuit tripping.	
MATACO (ATF-86)	False overspeed trip due to placement of various dc equipment on ship load. Shutdowns also occurred during transfer of shore to ship power and vice versa. Overspeed due to high temperature.	Scored commutator and slip rings, worn brushes  Worn bearings, scored commutator  Worn brushes, scored commutator
TAWASA (ATF-92)	(No major problems reported)	
ABNAKI (ATF-96)	(No major problems reported)	
CHOWANOC (ATF-100)	Failure of solid state components on all three circuits.	

TABLE 1. (Sheet 2 of 2)

Ship	Control Circuit Failure/ Problem	Other Failures/ Problems
COCOPA (ATF-101)	(No major problems reported)	"Burned" diodes (in brushless exciter circuit), faulty circuit breaker
HITCHITI (ATF-103)	Circuit board A-1 exhibited signs of excessive heating. Shunting diode was found defective. Ventilation was improved, and no problems have occurred since December 1973.	Burned transformer/wiring, worn bearings, scored commutator, improper field pole winding
MOCTOBI (ATF-105)	(No major problems reported)	Faulty frequency meter
MOLALA (ATF-106)	(No major problems reported)	
QUAPAW (ATF-110)	MG set intermittently tripped off line without apparent cause. Burned parts were found on voltage regulator.	
TAKELMA (ATF-113)	MG set could not adjust to 60 Hz. Adjustment of speed regulator had no effect.	Armature damage, inadequate ground
TAWAKONI (ATF-114)	MG set had speed regulator hunting and false overspeed trip problems.	Scored commutator, worn bearings.

TABLE 2. ARS/ATF 30 KW GENERATOR SET DISTRIBUTION

115 Vdc Prime Power											235 Vdc Prime Power									
Config.*	GRAPPLE (ARS-7)	DELIVER (ARS-23)	GRASP (ARS-24)	SAFEGUARD (ARS-25)	BOLSTER (ARS-38)	CONSERVER (ARS-39)	RECLAIMER (ARS-42)	APACHE (ATF-67)	UTE (ATF-76)	CREE (ATF-84)	MATACO (ATF-86)	TAWASA (ATF-86)	ABNAKI (ATF-92)	CHOWANOC (ATF-100)	COCOPA (ATF-101)	HITCHITI (ATF-103)	MOLATA (ATF-105)	QUAPAW (ATF-110)	TAKELMA (ATF-113)	TAWAKONI (ATF-114)
A <sub>1</sub>														2(N)	2(N)	1(N)	3	3(N)	1(N)	1(N)
A <sub>2</sub>		2(N)				1(Z)	1	3(N)	1(N)	1(N)	1(N)									
B													1(N)							
C									2	2(N)	2(N)									
D													1(N)						2(N)	2(N)
E	2(N) <sup>†</sup>		2(Z)	2		2(N)							1(N)			2(N)	2			
None Aboard Until Next ROH																				

*CONFIGURATION DATA:							APL/CID Number		
Config.	Motor/Generator	Control Cabinet	Technical Manual	Motor Generator	Control Cabinet	Motor Starter			
A <sub>1</sub>	Elect. Spec. 3U40203-01	Elect. Spec. CC0-0034	N/S 0962-046-0010	1812S0054	500060006	156203197			
A <sub>2</sub>	Elect. Spec. 3U40203-01	Elect. Spec. CC0-0034	N/S 0962-046-0010	563P001-06	500060006	563P002-06			
B	Elect. Spec. 3U40201-01	Elect. Spec. CC0-0034	N/S 0962-017-9010	1812S0051	500060006	156203197			
C	Cont. Elec. N73877	Elect. Spec. CC0-0072	N/S 0961-038-4010	181120090	612190021	156203277			
D	Cont. Elec. N72175	Jeta Power 566700	N/S 0963-037-0010	181120084	500770001	156203197			
E	Cont. Elec. N73877	Cont. Elec. N77189	N/S 0961-040-4010	181120090	502260017	156203277			

LEGEND:

X - No improvements recommended; Y - Minor installation improvements would improve reliability; Z - Major installation improvements needed

† - Installation in progress at time of report.



Figure 1 is a pictorial representation of how the five basic configurations are distributed among the ships. The "overlay" format permits one to note at a glance the MG set quantity and configurations aboard any of the subject ships. For example, RECLAIMER has two MG sets of configuration C (NavShips TM-0961-038-4010) and one of configuration A (TM-0962-046-0010).

While all MG sets are basically of the design described in their respective technical manuals, some modifications have been recommended based upon previous studies by various organizations. These modifications are listed in Appendix A. Their implementation status is not known, although ARINC Research personnel did note some modifications to the MG sets on the ships visited.

With the failure-history and configuration information in hand, ARINC Research proceeded to examine the causes and modes of failures of the MG sets. Analyses and evaluations were conducted on a configuration basis since ships with the same equipment suite seemed to experience similar problems and failure modes. The next section provides details of this evaluation.

### 3.4 CONFIGURATION EVALUATION

#### 3.4.1 Configuration A

A total of 23 MG sets of configuration A, identified by Technical Manual NavShips 0962-046-0010, are distributed among 14 ARS and ATF class ships of SERVPAC (see Figure 1). Ships reporting problems with this set are CHOWANOC, CREE, QUAPAW, HITCHITI, and MATACO.

USS CHOWANOC experienced multiple transistor failures on three circuit boards of one MG set. This occurred on a single occasion in August 1973. The cause of the failure has never been determined. Since the transistor failures were catastrophic and have not recurred, the most likely cause was a power surge to the ship's load, which coupled into the transistor power supply. Voltage or current surges lasting several milliseconds are sufficient to damage transistors permanently.

USS CREE reported premature activation of the overspeed circuit in June 1973. Ship personnel felt that the condition was heat related, and installed ventilation to cool the area of the control panel. No similar problems have since been reported. The failed overspeed circuit board was analyzed in detail by ARINC Research. The analysis (described in Appendix C) revealed that the overspeed threshold setting is a function of circuit component parameters sensitive to temperature changes. As temperature increases the threshold setting decreases, for example from 33 to 28 Hz when the temperature rises from 25° to 50°C. Since the nominal frequency of the overspeed circuit is 30 Hz, the temperature change would cause the circuit to sense an overspeed condition and trip off the MG set.

With the addition of control panel ventilation, this problem never recurred on CREE; however, the circuit deficiency remains. ARINC Research recommends that a circuit modification be made to all like equipments (overspeed board 3050049) operated in areas exposed to high ambient temperatures. The modification would encompass the following:

- a. Replace R10 (150 k $\Omega$ ) with a 1 k $\Omega$  metal film resistor RC20GF102K.



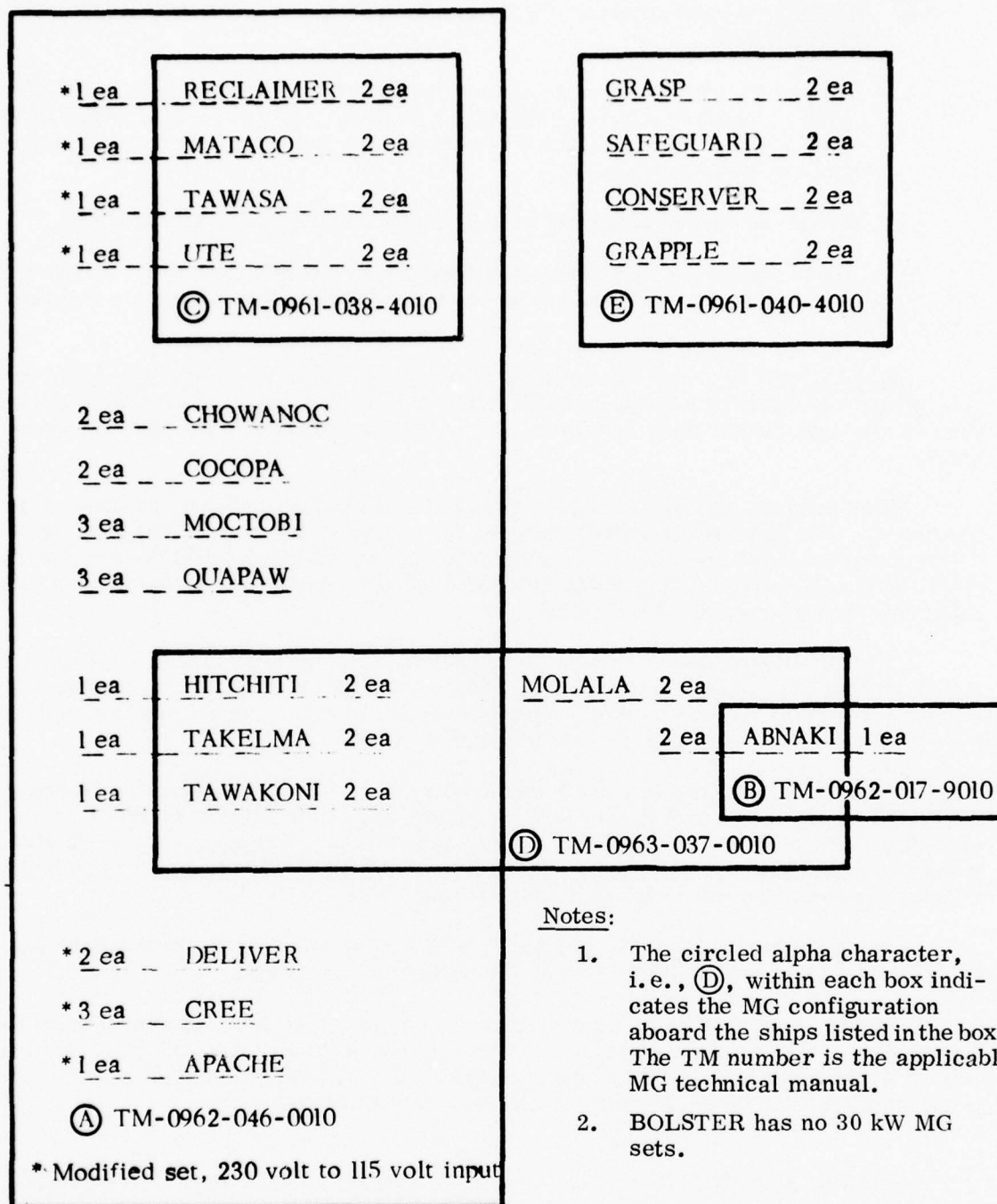


Figure 1. Distribution of 30 kW MG Sets Among Type ARS and ATF Ships of SERVPAC

- b. Replace R6 (potentiometer) with either RT12C2L203, RT11C2L203, or PT22C2L203.
- c. Replace C2 with a metalized polycarbonate type (there are no Mil-qualified parts). Recommended is TRW type X463UW, 1 uF, 50V, 0.312-inch diameter, 11/16-inch length (not a one-to-one fit; a circuit board modification would be necessary).
- d. Set the overspeed threshold to 15% above nominal (i.e., to ~34.5 Hz).

If all three components cannot be replaced, item a should be substituted as a minimum. Items b and c should be replaced as a unit due to their mutually compensating effect.

USS QUAPAW reported intermittent tripping off line of the motor generator set, and voltage regulator overheating that resulted in burned parts. Ventilation was modified to alleviate the overheat condition, and no major problems have been reported since.

These failures and failure modes are similar to those of CREE, as previously discussed. The fact that no further failures have occurred in either QUAPAW or CREE since the ventilation improvements substantiates the belief that the problem is most likely heat-related. The same component modifications are recommended for QUAPAW as were suggested for CREE.

USS HITCHITI reported that resistor R24 on the overspeed circuit board has failed several times due to overheating. Ship personnel installed hosing to direct air from a vent supply into the control cabinet; however, no correlation could be made between R24 failure and high ambient temperatures.

A failure of this type is most likely due to internal overheating of the resistor due to a current overload that causes the resistor power dissipation rating to be exceeded. Since the current to this resistor comes from a resistor voltage divider it may be likely that the adjustable setting on the voltage divider is out of specification, causing more current than normal to pass through R24.

It is recommended that the voltage divider circuit (R11, R12, R13) be checked for proper setting, and R24 be checked for proper power rating.

USS MATACO's MG set, under high temperature conditions, has been found to trip off line. Ship personnel report that the addition of fans in the control panel area improved the situation. This failure symptom is similar to that of CREE, and the same modifications listed above for CREE are recommended.

Generally speaking, therefore, 30 kW MG sets of configuration A are usually very reliable when their control panels are operated at normal ambient temperatures. A temperature increase from 25° to 50° C will cause false overspeed actuation due to circuit component changes. This problem has occurred in 3 of the 14 ships having this MG set configuration (or in 7 of 23 possible MG sets). The condition has not been more widespread because the sets are generally installed in areas where the control panel is not subject to excessive heating. Should this condition change due to removal of ventilation in control panel spaces or relocation of the control panel to a hotter area, circuit modifications are highly recommended (see discussion, Appendix C).

Although no problems relating to this condition have been reported by RECLAIMER, the control panel of a 30 kW MG set aboard that ship was noted to be installed directly above the exhaust of the MG set. The exhaust is directed into one-half of the control panel cabinet, causing inside temperatures to be very high.

#### 3.4.2 Configuration B

Configuration B of the 30 kW MG set is used aboard only one of the subject ships (ABNAKI). This set has been modified from its original configuration by replacement of the control cabinet (Electronic Specialty CC0-034 in place of that company's CC0-010). The CC0-034 is the same cabinet as used in configuration A.

Due to the unavailability of the ABNAKI to ARINC Research during this investigation, it could not be established whether the MG unit was modified by the addition of a magnetic probe. That modification is essential to the effective operation of the frequency control circuits in the CC0-0034 cabinet. If the MG unit has a probe installed, the entire set is likely to be identical to configuration A, and Technical Manual N/S 0962-046-0010 could apply to all installation elements. If the probe has not been installed, this TM applies only to the control cabinet, and the unit's speed control circuits are likely inoperative, an unsafe situation.

No problems related to the control cabinet have been reported by ABNAKI.

#### 3.4.3 Configuration C

Configuration C of the MG set is used in four ships, each having two 30 kW MG sets identified by TM N/S 0961-038-4010. One ship, USS MATACO, has reported problems in both units of this configuration. MATACO encountered false actuation of the silicon controlled rectifier (SCR, position CR7) in the overspeed trip circuit of MG set #2 as various equipments were placed on the ship's load. The cause was noise pick-up into the overspeed PC card (A6) via the magnetic pickup harness from the MG set to the control cabinet (see details, Appendix B). These noise spikes tripped the overspeed circuit either by a  $dv/dt$  effect\* in the SCR or by biasing the circuit to a degree that it sensed an overspeed.

MATACO also experienced shutdowns of MG set #1 when the ship transferred from shore dc power to ship power, and vice versa. The problem was traced to a faulty pickup which charged to a dc potential when the ship was supplied by shore power. When the ship was transferred to internal power, the +120 Vdc was no longer grounded and the magnetic pickup, acting like a capacitor, discharged through the overspeed circuit, preventing activation of the MG set for approximately 10 minutes. The faulty pickup was replaced, which corrected the problem (see Appendix B for detailed discussion).

Equipments of configuration C are generally very reliable when correctly installed and operated under proper conditions. The problems experienced by MATACO had their origins in the installation process. This situation could occur on other ships with configuration C equipment; therefore, should similar failure symptoms be experienced, an incorrect installation may be the cause and a corrective measure as discussed above for MATACO might be appropriate.

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\*A pulse with high enough  $dv/dt$  across the anode to cathode may trigger an SCR without a gate signal present.



#### 3.4.4 Configuration D

Configuration D of the MG set is used aboard five ships, each having two units identified by TM N/S 0963-037-0010. Ships reporting problems with this configuration are HITCHITI, TAKELMA, and TAWAKONI.

USS HITCHITI reported a failure of diode CR101, which caused the output voltage to be low. Failure of this diode could not be correlated with heat problems or circuit deficiencies. The most probable cause was a current surge on the line.

USS TAKELMA experienced a control circuit board failure in which the speed regulator circuitry was not capable of driving the frequency up to the specified 60 Hz. The frequency remained at approximately 57 Hz regardless of manual adjustments of the panel or circuit board. Shipyard personnel partially disassembled the panel, then reassembled it without repair. The set functioned properly after reassembly. The probable cause of problem was apparently a loose or otherwise bad connection.

The ship experienced the same incident as above when new circuit boards were installed and the MG set would not come up to speed. The boards were inspected aboard ship and the one containing the speed regulator was later found by Pearl Harbor Naval Shipyard to have defective capacitors (C1 and C3).

USS TAWAKONI reported failure of the speed regulator board. The failed board was analyzed by ARINC Research, and a bad solder connection and burned transistor were noted. The bad solder connection appeared to be due to careless work. The failed transistor was examined under a microscope and found to have an open base-to-emitter lead. The most likely cause was a current surge of approximately 1 ampere for a few milliseconds. Since other sensitive parts were not damaged by this current surge, failure probably occurred as a result of probing during an inspection or troubleshooting period.

SCR 2N688 was reported to have failed several times over a period of one year. The probable cause was excessive heat in the control panel space. Ventilation into the control cabinet was provided and no further failures have been reported.

Equipments of configuration D do not need major modifications or installation improvements. With the exception of equipment aboard TAKELMA, other equipments of this configuration have been trouble-free.

#### 3.4.5 Configuration E

Configuration E of the 30 kW MG set is installed aboard four ships, each with two sets identified by TM N/S 0961-040-4010. Ships that have reported problems with this configuration are GRASP, SAFEGUARD, and CONSERVER.

USS GRASP has encountered occasional, random shutdowns of both MG sets without apparent reasons. From a ventilation viewpoint, the installation of the two control cabinets does not appear prudent - one is directly on top of the other, as an integral part of the main propulsion control board in Main Control. The intended natural ventilation of these cabinets is defeated by the lack of an air supply to the lower unit and the restricted intake to the bottom of the upper unit, as well as the blocking off of the sides of both cabinets by adjacent panel supports. Excess cable lengths between the entrance bushings and the terminal boards further block off the

air inlet screen. Within this pile of wire is interlaid the cable pair from the magnetic pickup probe of each MG set. The cause of the random shutdown was never determined; however, possible causes are overheating or noise-spike coupling into the magnetic pickup probe cable pair.

USS SAFEGUARD reported premature actuation of the overspeed relay of MG #2 shortly after the set was installed, resulting in equipment shutdown. Pearl Harbor Naval Shipyard determined that the wiring associated with the magnetic pickup was picking up pulses of current from other parts of the system, which would cause false triggering of the overspeed monitor circuits. (The shipyard report is included as Appendix D.) MG #1 was not so affected because its magnetic pickup wiring was isolated from other wiring and shielded from stray inputs throughout its length.

USS CONSERVER has also experienced occasional overspeed tripouts. Ship's force achieved reasonable performance by changing the system frequency to 58.5 Hz and providing for an outside-air supply to the control cabinet area. The net effect has been acceptable performance of the circuit.

In summary, configuration E is basically a well designed system that seems to have one sensitive area, occasional overspeed tripouts. It shares this problem with configurations A and C, which use magnetic pickup probes in the MG units; these probes may pick up stray pulses, creating a false indication of MG overspeed. Ideally the wiring to the pickup probe should be a shielded pair, with the shield properly grounded only at the control cabinet end to prevent a ground loop. It is expected that such an installation would be sufficient to eliminate stray pulses from the overspeed sensing circuit. It should be noted that the technical manual for configuration E does not address the careful attention that must be given to the installation of the magnetic pickup wiring.

### 3.5 SUMMARY AND RECOMMENDATIONS — MG STUDY

Fifty 30 kW motor generator sets are used in five basic configurations on 21 ARS and ATF ships of SERVPAC. Of these sets, 16 have had control circuit problems of CASREPT severity — five of configuration A, two of configuration C, four of configuration D, and five of configuration E. Of 16 MG sets, only one is presently having problems (USS TAKELMA has defective circuit boards). Modifications and/or installation corrections have been made to the other 15 sets and no major incidents have been reported since corrective action.

Evaluation of failures indicated that the failure modes were varied — overheating, incorrect grounding/shielding, and bad connections. These types of deficiencies are all independent and therefore no general statement can be made as to common failure causes. Future problems may be evaluated in accordance with the configurations defined in this report. If problem symptoms are similar, the appropriate recommendations given in this report may be found to be applicable.

The general condition of 30 kW MG sets aboard SERVPAC ARS and ATF ships was found to be good. Recurring control circuit board failures have been solved either by addition of ventilation and/or installation corrections. Future failures and other incidents may be minimized by implementing the following recommendations:

- a. Modify the overspeed circuit board for the set defined by NavShips 0962-046-0010 (configuration A), in accordance with Appendix C.



- b. Check the magnetic pickup wiring installations aboard RECLAIMER, TAWASA, and UTE. If necessary, install magnetic pickup shield wiring in consonance with MATACO's present installation (see Appendix B).
- c. Check the magnetic pickup cabling aboard GRAPPLE, GRASP, and CONSERVER. If necessary, provide shielded wires for connecting the magnetic pickup and overspeed monitor (in consonance with the action taken on SAFEGUARD; see Appendix D).
- d. Check the configuration B unit aboard ABNAKI to ensure that an operative overspeed trip has been incorporated into the modified MG set. If one is not found, two options are available for providing this safety device:
  - 1) Install a magnetic probe assembly identical to that in configuration A units and wire it to the CC0-0034 control cabinet in accordance with NavShips 0962-046-0010; or
  - 2) Replace the CC0-0034 control cabinet with a CC0-0010 control cabinet as originally configured.

Option (1) is preferable from the standpoint of least cost, elimination of one of the five configurations found aboard ARS/ATF ships, and providing ABNAKI with three identical 30 kW MG sets.

- e. It is considered that, except in an unusual situation, most repairs to these printed circuit boards are beyond the electronic experience level generally allowed aboard ARS and ATF class ships. Therefore it is recommended that a depot level maintenance program be established for rework of various printed circuit boards involved in all of the MG set configurations identified in this report. In addition, a few of each of these printed circuit boards should be stocked in the Navy supply system to ensure ready availability; or a set of applicable boards should be stocked aboard ships as spares.
- f. Aboard RECLAIMER, install a heat deflector to direct the exhaust from the configuration A2 30 kW MG set away from the ventilation grating of the control panel.

## DESIGN STUDY, 2.5 KW EMERGENCY DIESEL GENERATOR

### 4.1 STUDY APPROACH AND CONDITIONS

As part of this investigation, ARINC Research was directed to evaluate the present emergency communication configuration on SERVPAC ARS and ATF class ships; and to design, around the 2.5 kW diesel generator, a system configuration that will provide improved emergency communications capability.

In conducting this task, ARINC Research took the approach of visiting ARS and ATF ships of SERVPAC to determine requirements and equipment availability for the emergency communication system. These equipments were then used to configure a usable and flexible system for all of the subject ships.

### 4.2 BACKGROUND

Until the installation of the present 30 kW, three-phase, 115 Vac motor generators, the configuration of the 115 Vac electrical load aboard ARS/ATF ships was that of several discrete single-phase systems. That arrangement was used for ship electronic equipment load. On those occasions when the normal 60 Hz power source was not available, a 2.5 kW diesel generator could be used to supply a limited amount of power to the entire electronic power distribution system.

Gradual growth of the 60 Hz electrical load requirement, coupled with a three-phase input power requirement for new electronic equipment, called for the 30 kW generator installation for support. These three-phase power sources necessitated that a ship's single-phase 60 Hz electric load be reconfigured to provide balanced phase loads for each generator.

The actual designs used to supply 450 Vac three-phase and 115 Vac single-phase power vary from ship to ship, but in most cases can be generalized as follows. Certain new high-powered transmitters are supplied three-phase 450 Vac power via a special feeder cable from an engineering-space power distribution panel. The 115V single-phase requirement is generally satisfied by stepping down the generator voltage with a 30 kVA transformer bank, and via another feeder cable to power distribution panels in and about the communication spaces and pilot house area. On a few ships the transformer bank is also located adjacent to the communication spaces, saving the cost of running a 115V power feeder from the engineering space.

As a result of the division of the electronic equipment load into three phases, a decision had to be made as to how to connect the existing single-phase diesel generator to the new three-phase load. In all ships visited during this investigation (the same ships as in the 30 kW MG study), the least-expensive method was elected, i. e., one of three phase loads was provided with a bus transfer switch that permitted emergency power availability to loads on that one phase, typically one or two

equipments in the transmitter room (see Figure 2). Figure 2 exemplifies the situation where the emergency diesel generator can be connected only to the radio transmission room, a common situation among the subject ship types.

#### 4.3 EMERGENCY COMMUNICATION REQUIREMENTS

For the ARS and ATF class ships, guidelines have been provided for emergency power distribution to electronics equipment. These guidelines are directed toward ensuring the best equipment-selection flexibility for the many situations in which a ship may find itself without ac power. The most serious condition, of course, is where there is no normal power whatever. However, the more usual need is that predicated by material failure, which can happen at any time and continue for an unpredictable interval.

Examples of emergency power utilization in the subject ships include the following:

- a. AN/URC-9 (UHF voice) and AN/WRC-1 (HF voice) were connected to the emergency source through a bus transfer switch.
- b. AN/URC-9, AN/WRC-1, and alternate similar-function equipment were connected to the emergency source through a bus transfer switch.
- c. Most of the electronics load was connected to the emergency source through a bus transfer switch.
- d. Two-way CW or voice short-range HF equipment were connected to the emergency source through a bus transfer switch.
- e. HF transmit capability was connected to the emergency source through a built-in alternate power switch.

The above variations show that the ships had emergency capabilities ranging from little to maximum flexibility. Conditions of little or no flexibility were the case aboard all ships except GRASP. Although GRASP had maximum selection flexibility under emergency conditions, its normal load condition was less than desirable due to unbalanced heavy loading on that one phase.

Discussions with COMSERVPAC communication officers defined the following functional requirements for these emergency situations:

- a. First priority - Provide power for those electronic units involved in receiving the covered broadcast; other "first priorities" can be envisioned as well for specific circumstances, each of which would have its own unique equipment suite.
- b. Second priority - Establish a two-way communications channel, probably voice or teletype, on which to report the situation where necessary. The latter mode, teletype, has been stated to be the most desirable since it provides the longest range and has the greatest reliability for a given transmitter power-output availability.

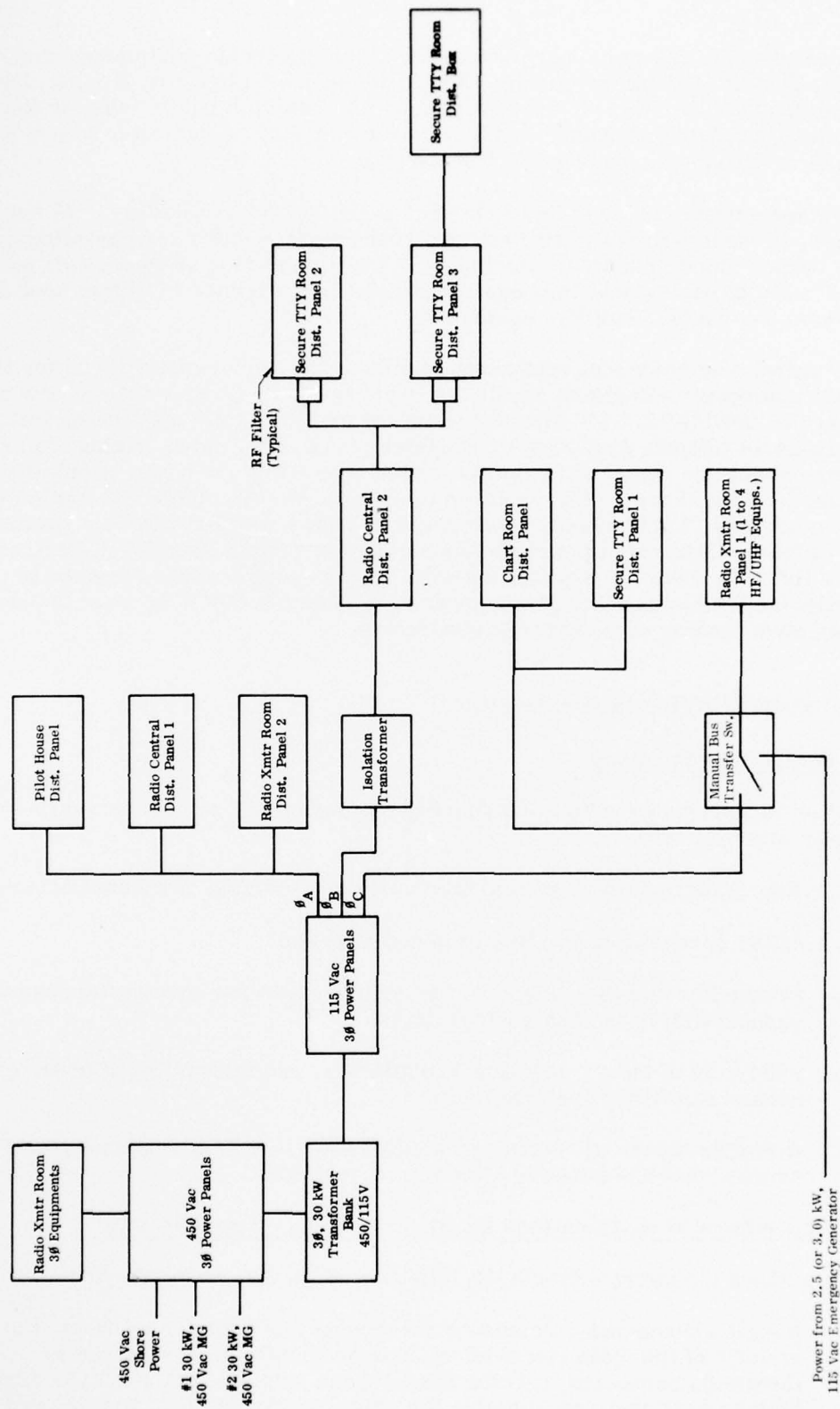


Figure 2. Typical Electronic Equipment Power Distribution



Alternate and optional requirements for other electronic equipments may stand high in the priority listing for certain situations, such as a lost tow at night; location of the ship on a poor visibility, shallow water site at time of power loss; or the need to determine the ship's position. In all situations, it may be desirable to use radar, loran, and/or fathometer at least part of the time.

Another aspect that must be considered is equipment availability. At any given time, it would be rare to find all electronic devices ready for operational use. For that reason alone, maximum flexibility in the distribution of emergency power is most desirable to ensure that the required capabilities in times of urgent need can be met from any usable, suitable equipment.

To satisfy the functional equipment requirements, emergency power for the broadened emergency situations should not necessarily be greater than is now available from the provided 2.5 kW diesel generators or those 3 kW units being installed as replacements (Shipalt ARS-310D). Certainly, control of the operating electronic equipments should be managed to ensure against exceeding the power capability of the generator. A time sharing plan, tailored to specific requirements and implemented at the time of need, would assure maximum operational support from the limited power available. Estimated power requirements for various functional electronic loads are listed in Table 3, together with the various equipment(s) required to provide particular functions. The given power requirements should be used to determine maximum loading on emergency generators.

#### 4.4 RECOMMENDED SYSTEM DESIGN

##### 4.4.1 Design Requirements

To be in consonance with the foregoing requirements, any recommended system design must provide:

- a. Emergency power distribution among the maximum number of equipments
- b. Safety of operation for both men and material.
- c. Ease and reliability of operation under the adverse circumstances often encountered in the sea environment.
- d. Indication of emergency power availability and amount being used, or of unused capability still available.
- e. A simple means of returning the electronic load to the normal power source when the latter is known to be available.

##### 4.4.2 Recommended Modifications for Meeting Design Requirements

To achieve the above criteria the following steps are recommended:

- a. Install a three-pole, double-throw manual bus transfer switch in the vicinity of the main communication spaces with the normal power terminals connected to 1) the three-phase output of the 450/115V transformer bank that now supplies the ship's electronic load in this area,

TABLE 3. APPROXIMATE POWER REQUIREMENTS  
FOR TYPICAL FUNCTIONAL LOADS (Sheet 1 of 2)

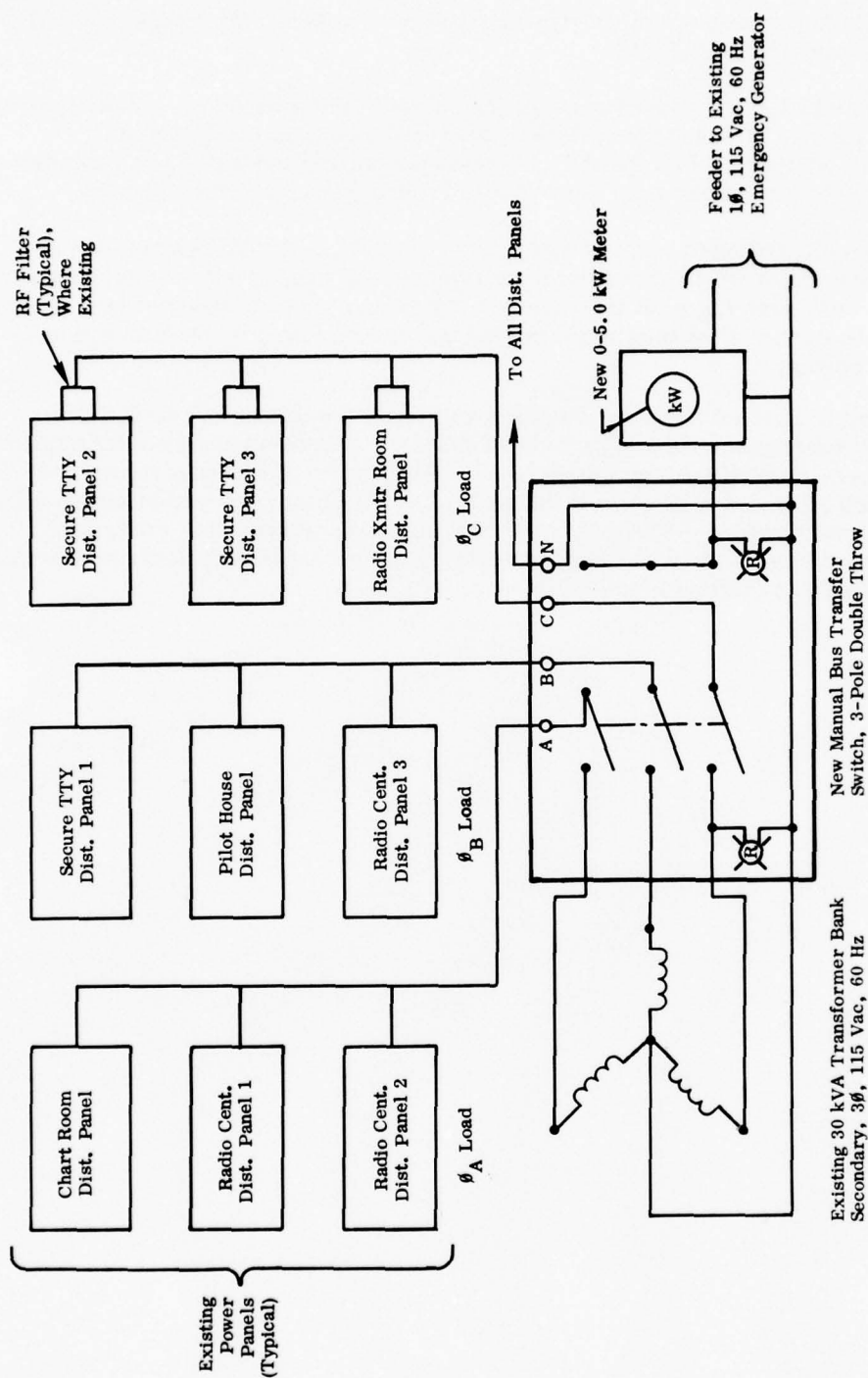
Function	Equipment (Typical)	Power Reqmt. (watts)
Receive covered broadcast (simple "N" system)	R-1051( )/URR AN/UCC-1( ) (V)R1 AN/URA-17( ) TSEC/KWR-37 or TSEC/KG-14 AN/UGC-25( ) PP-3495/UG AN/URQ-10( )  Total:	55 5 70 105-130 50 50 (est) 20 <hr/> 355-380
SSB HF voice, low power	AN/WRC-1B	300
SSB HF voice, high power (for ships so equipped)	AN/URC-32 AN/SRA-22 AM/2631/U (optional)  Total:	1500 130 10 <hr/> 1640
Uncovered F/DX TTY, low power	AN/URT-24 R390A/URR or R-1051( )/URR C1003B/SG AN/URA-17( ) or AN/URA-8( ) AN/UGC-20( ) PP-3495/UG  Total:	250 270-55 10 70-220 50 50 (est) <hr/> 485-850
Uncovered UHF voice, (from ship's bridge)	AN/URC-9 AM-2631/U  Total:	400 10 <hr/> 410
VHF bridge-to-bridge	AN/VRC-46 } or AN/URC-80 PP-3953A }	600 (est)
Surface search radar	AN/SPS-53( ) AN/SPS-25( )  Total:	650 420 <hr/> 1070
Loran or Omega	AN/SPN-40 or AN/SRN-12  Total:	110 360 <hr/> 110-360

TABLE 3. (Sheet 2 of 2)

Function	Equipment (Typical)	Power Reqmt. (watts)
Fathometer	AN/UQN-1( )	300
IFF Transponder	AN/UPX-12( )	398
Visual signaling (where not dc operated)	Single 12" mercury xenon or tungsten searchlight	300 (est)

and 2) the alternate (emergency) power terminals connected in parallel to the single phase emergency power feeder cable located in the same area (see Figure 3). The output of this transfer switch would feed all 115 Vac power distribution panels on this level of the ship and above, grouped so as to present a balanced three-phase load to the normal power source when so switched.

- b. Provide a manual bus transfer switch of the type having power-source lamp indicators which, when lit, would indicate power availability.
- c. Provide, in the vicinity of the power transfer switch, a panel-mounted, single-phase kilowatt meter scaled 0 to 5.0 kW, or a similar type ammeter scaled 0 to 30 ac amperes. The meter would be redlined at a value appropriate to the emergency generator rating, wired into the emergency power circuit, and labeled "Emergency Generator Output".
- d. Remove the emergency power transfer capability now existing in each ship and restore any power panel so serviced to a sole-power-source configuration served via the new transfer switch. In those instances where equipment is provided emergency power directly from the emergency generator and uses a built-in power selection switch, remove the emergency power cable connections at the serviced equipment.
- e. Provide, as a minimum, a manual remote start capability for the emergency diesel generator in the vicinity of the new bus transfer switch to obviate the need for personnel to leave the ship's weather-tight enclosure for equipment light-off. This capability, with automatic start, is incorporated into at least one of the new 3.0 kW generator installations being provided by Shipalt ARS-310D as part of the Onan Corporation-supplied control cabinet; however, no similar shipalt is known to exist for the ATF classes.
- f. On those ships that already have or will have the new Onan 3.0-kW emergency generators, the 115 Vac output from its automatic bus transfer relay should be fed directly to the manual switch proposed in above (item a) and not used as the primary power transfer means. In the latter event, the normal power load at the time of power failure would exceed the emergency generator rating.



NOTES:

1. For normal underway condition, loads  $\phi_A$ ,  $\phi_B$ , and  $\phi_C$  should be as nearly equal as possible; and in no case should a single phase exceed the rating of its transformer (usually 10 kW, although some 7.5 kW units exist).
2. Distribution panel location and numbers are only illustrative, and do not necessarily conform to any particular ship.
3. Substitution of a 0 to 30 amp ac ammeter for the indicated kilowatt meter is an acceptable but less desirable alternative.

Figure 3. Recommended System Design Schematic (Elementary)



#### 4.4.3 General Recommendations

In addition to the communication-system design modifications recommended above, it is also recommended that:

- a. Replace all 2.5 kW diesel generators on ATF ships with 3.0 kW equipment (Onan Corp.) to ensure reliability and readiness when called upon. Present equipment is generally beyond economical repair since replacement parts are reportedly unavailable from regular vendor sources.
- b. Develop aboard each ship an ordered system of electronic equipment priorities tailored to fit various envisioned emergency situations, together with a time sharing plan for those Table 3 functions considered less than vital, to ensure that maximum advantage can be taken of available emergency power.
- c. Develop individual installation plans for implementation of the 2.5 kW or 3.0 kW emergency diesel generator system. Plans should specify equipment cost, manufacturer, model, and detailed installation instructions for each ARS and ATF ship of SERVPAC. Maximum attainable uniformity is desired to effect beneficial logistics support, installation cost, and documentation cost in the implementation of the expanded electronic power distribution system advocated herein.

APPENDIX A  
PROPOSED MODIFICATIONS TO  
30 KW MOTOR GENERATOR SETS

	<u>Page</u>
1. COMSERVPAC, "Mod 30 KW M/G Cont Circuit", Ser. N43/4511, dated 2 Aug 1973 . . . . .	A-3
2. Department of the Navy, "Evaluation of Kems, Inc., Engineering Report on 30 KW MG Set Resistors", dated 15 November 1973 . . . . .	A-13

COMMANDER SERVICE FORCE  
UNITED STATES PACIFIC FLEET  
FPO SAN FRANCISCO 96610

FF4-15  
4720  
Ser N43/ 4511

ALTERATION EQUIVALENT TO A REPAIR  
COMSERVPAC 4720/1 (REV. 5-72)

2 AUG 1973

To: Distribution List

TITLE Mod 30KW M/G Cont Circuit  
PRIORITY ☒ MANDATORY ☐ DESIRABLE  
B3-M

APPLICABLE TO  
SERVPAC ARS and ATF

AER NUMBER

AE	AOE	ATF	100
AF	AOR	ATS	
AFS	AR		
AO	ARS	110	

REFERENCES

(a) COMSERVPACINST 4720.4

PLANS

ENCLOSURES

- (1) NAVSHIP ltr 427:LMG:  
gad ASR/ATF Gen Ser  
438-42732 of 28 Jun 73
- (2) AER Completion Report

SPECIAL MATERIAL

APPROVED FOR ACCOMPLISHMENT BY:

☒ SHIPS FORCE

☒ REPAIR SHIP

☒ SHIPYARD

PURPOSE AND DESCRIPTION:

CONTINUATION SHEET:

1. Purpose. To prevent burnout of potential transformer (T101) in the event of a short circuit in its secondary and permit doing maintenance work on one M/G while the other M/G is in operation.
2. Description. The following modifications require for accomplishment in accordance with enclosure (1):
  - a. Remove resistor R3 (470 OHMS) and install a jumper.
  - b. Replace resistor for R12 (15K OHMS) with a 5.6K OHMS resistor.
  - c. Install a Voltmeter selector sw on the front of the control panel of #1 M/G set only (for parallel operation).
  - d. Install two mode selector switches, one each on the front of control panel (for maintenance).
  - e. Correct the motor and generator winding datas.
3. Utilize format prescribed in enclosure (2) in reporting completion or non-applicability of AER.

Distribution: (See page 2)

*R. W. McGaughey*  
R. W. MCGAUGHEY  
By direction

FF4-15  
4720  
Ser N43/

Distribution: (1 copy only)  
COMSERVPACINST 5216.2L  
List II (E & F only) (SERVPAC SHIPS)  
List IV (A, B, C, D only) (REPAIR & MAINTENANCE ACTIVITIES,  
NAVAL STATIONS & FLEACTS)

Copy to: (1 copy only)  
List I (GROUP & SQUADRON COMMANDERS - SERVPAC)  
List XI (F4 only) (NAVY DEPARTMENT) (COMNAVSHIPSYS COM)  
COMNAVSHIPYD HUNTERS POINT (PERA (CSS))



- FACSIMILE -

NAVAL SHIP SYSTEMS COMMAND

WASHINGTON, D. C. 20360

In Reply Refer to  
427:LMG:gad  
ASR/ATF Gen  
Ser 438-42732

28 Jun 1973

From: Commander, Naval Ship Systems Command  
To: Commander Service Force, U.S. Atlantic Fleet  
Commander Service Force, U.S. Pacific Fleet  
Commander Submarine Force, U.S. Atlantic Fleet  
Commander Submarine Force, U.S. Pacific Fleet  
Commander, Pearl Harbor Naval Shipyard

Subj: ASR and ATF type ships, 30KW DC/60 Hz motor generator manufactured by Continental Electric Company, Inc., circuitry modifications; information on

Ref: (a) Technical Manual NAVSHIPS 0963-037-0010, "30KW M-G, 230 Volts DC to 450 Volts AC, 3-Phase 60 Hz and Associated Control Equipment"  
(b) NAVSHIPYD Pearl Dwg. NAVSHIPS Dwg. No. ATF 103-302-4465325 (4 sheets) Rev A (6/9/73) "ATF 103 Power System, 30KW M-G Sets and AC Power Distributions"

Encl: (1) "30KW DC/60 Hz Motor Generator Set; Modification to Volt. and Speed Regulator Input Power"  
(2) "Changes in Winding Data, Technical Manual NAVSHIPS 0963-037-0010, Continental Elec. Co., Inc., 30KW 230V DC/450V, 3-Phase 60 Hz Motor Generator"

1. The subject motor generators were procured under NAVSHIPS contract N00024-67-C-5269 for installation on ASR and ATF type ships under ShipAlts ASR-300 and ATF-185. Operating experience has indicated the following problems with this equipment:

a. In event of a short circuit on the secondary of the voltage regulator power transformer (T101), the current transformer (CT4) in the generator output loads will maintain generator field excitation and sustain current flow resulting in burn-out of the T101 transformer.

b. The frequency regulator is unstable.

c. The voltage of the No. 2 motor generator cannot be read at the No. 1 M-G control panel when paralleling the motor generators.

d. Not all interconnections between motor generators No. 1 and No. 2 are disconnected when the motor generators are not operating in parallel.

427:LMG:gad  
ASR/ATF Gen  
Ser 438-42732

e. There are errors in the motor and generator winding data as given in the technical manual, reference (a).

2. The problem noted in paragraph 1a can be corrected by the circuitry modification covered by enclosure (1). This modification was evaluated as satisfactory on USS MOSOPELEA (ATF 158) and USS SHAKORI (ATF 162).

3. Correction of the frequency instability problem, paragraph 1b, can be accomplished as follows (refer to pages 9-11 and 9-13 of reference (a)):

a. Remove resistor R3 (470 ohms) and install a jumper to complete the circuit.

b. Replace resistor R12, 15K ohm, Military Type Number RC20GF153K with a 5.6K ohm resistor, Military Type Number RC20GF562K.

4. Voltage indication during paralleling, paragraph 1c, can be provided by mounting a Voltmeter Selector Switch (Item 27 of drawing reference (b)) on the front of the control panel of motor generator No. 1 only. This switch, connected as shown on reference (b), permits reading output voltage of either M-G No. 1 or M-G No. 2 at the M-G No. 1 Control Panel Voltmeter.

5. Electrical isolation between the two motor generators, paragraph 1d, to permit doing maintenance work on one M-G while the other M-G is operating can be provided by installing Mode Selector Switches (Item 30 of drawing reference (b)), two switches, one each mounted on the front of the control panel of M-G No. 1 and M-G No. 2. These two switches are to be connected as shown on drawing reference (b).

6. The correct motor and generator winding data is given in enclosure (2). This winding data, which corrects the errors as indicated in paragraph 1e above, will be included in the technical manual changes to be distributed by Naval Ship Engineering Center (NAVSEC) in accordance with paragraph 10 herein.

7. Pearl Harbor Naval Shipyard is requested to add a detail sketch to drawing reference (b) to show mounting and physical location details for selector switches Pc. No. 27 and 30 listed on sheet 1 of drawing reference (b). An identification and switch position indication plate should also be shown for selector switches Item No. 30. This detailed information, added to drawing reference (b), will provide uniform information for use during installation of the subject motor generators. Pearl Harbor Naval Shipyard is requested to furnish print copies of the up-dated reference (b) drawing to addressees of this letter and also to NAVSECNORDIV, NAVSECPHILADIV, NAVSECSDIEGODIV, NAVSHIPS (42731) and NAVSEC (6158C).

8. For those ships on which ShipAlts ASR 300 or ATF 185 have been completed but the modifications of paragraphs 2 through 5 above have not been accomplished, it

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ASR/ATF Gen  
Ser 438-42732

is recommended that these modifications be authorized by the Type Commanders as an alteration equivalent to repair. The modifications in paragraphs 2 and 3 can be accomplished by the ship's force, but the modifications in paragraphs 4 and 5 should be accomplished by a shipyard or repair facility.

9. For those ships on which the ShipAlts have not yet been accomplished, it is recommended that the modifications covered in paragraphs 2, 3, 4 and 5 be authorized by the Type Commanders to be accomplished concurrently with the completion of ShipAlt ASR 300 or ShipAlt ATF 185.

10. By separate action, the equipment manufacturer has been requested to provide corrected insert pages for reference (a) reflecting the modifications covered herein. NAVSEC will distribute the insert pages to the present holders of the manual.

11. Pearl Harbor Naval Shipyard is requested to furnish NAVSHIPS (42731) by 31 July 1973 an estimated date by which copies of the up-dated reference (b) drawing will be issued. In addition to the print copies requested in paragraph 7 above, one reproducible copy of this up-dated drawing should be furnished to NAVSEC (6158C) for use in up-dating technical manual reference (a).

Copy to:  
NAVSECNORDIV  
NAVSECPHILADIV  
NAVSECSDIEGODIV

W. C. WYATT  
By direction

30KW DC/60 Hz Motor Generator Set;

Modification to Volt. & Speed

Regulator Input Power

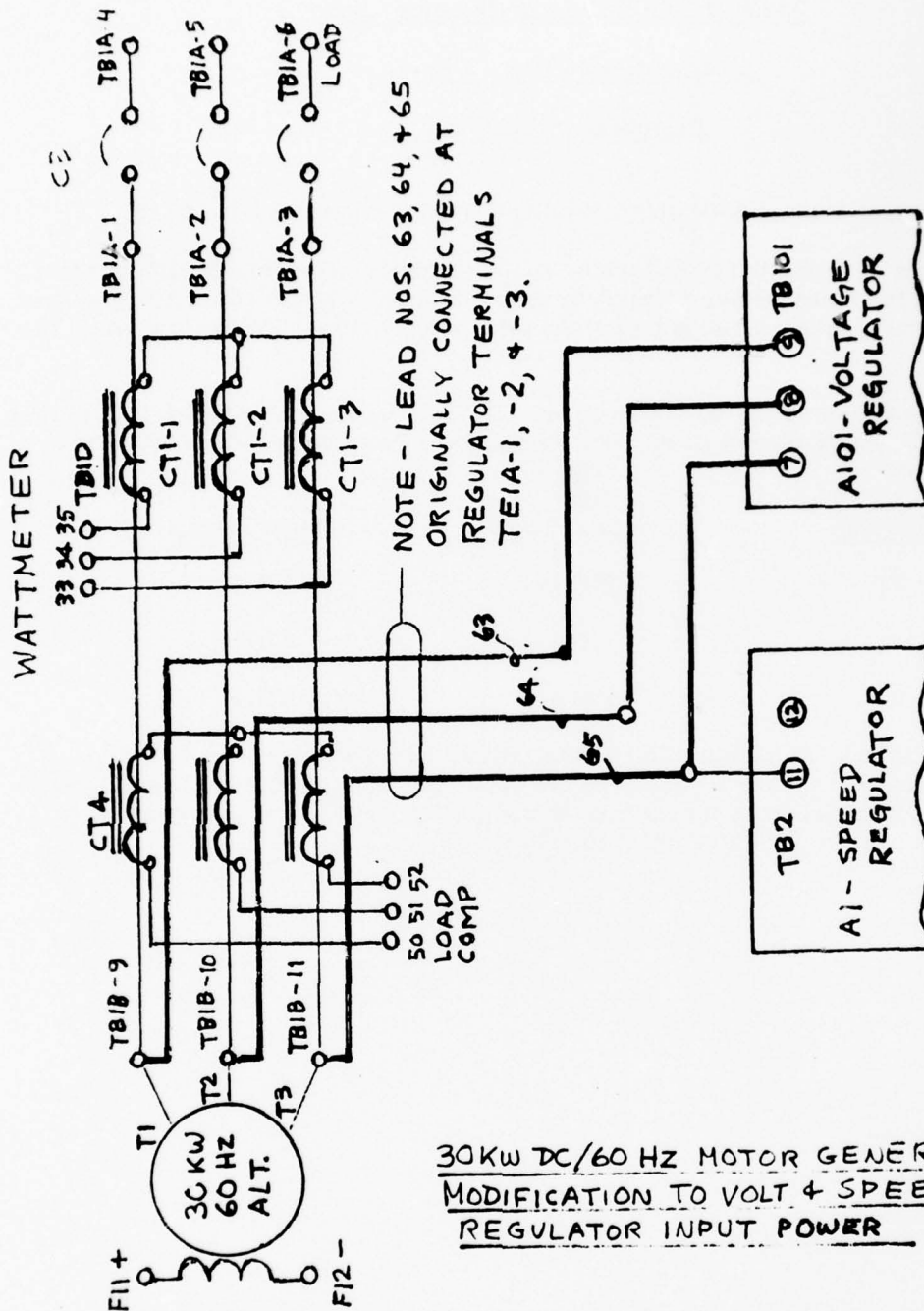
Refer to Technical Manual NAVSHIPS 0963-037-0010, Pages 9-13 and 9-15:

1. In the event of a shorted transformer (T101) secondary circuit, a high current is reflected in the transformer primary circuit. Current transformer (CT4) senses this current level increase and supplies the alternator field excitation to sustain the current flow.
2. To eliminate this condition and preclude burnout of potential transformer (T101) in the event of a short circuit in its secondary, the following circuit modification should be made:

<u>Lead Nr.</u>	<u>Original Term.</u>	<u>New Term.</u>
63	TB1A-1	TB1B-9
64	TB1A-2	TB1B-10
65	TB1A-3	TB1B-11

3. The attached sketch reflects the circuit modification which connects the regulator potential transformer leads to the generator side of current transformer (CT4). This action prevents the current transformers from supplying generator field excitation when a regulator short circuit develops.





CONTINENTAL ELECTRIC, NSTM 0963-037-0010

30 KW DC/60 HZ MOTOR GENERATOR SET  
MODIFICATION TO VOLT & SPEED  
REGULATOR INPUT POWER

Sheet 1 of 2

Sheet 2 of 2

TECHNICAL MANUAL NAVSHIPS 0963-037-0010  
Continental Elec. Co. Inc. 30KW 230V DC/450V, 3-Phase  
60 Hz Motor Generator, Changes in Winding Data

On page 9-5 Correct Motor Winding Data to read as follows (N. C. indicates No Change):

Part	Main Shunt Field	Series Field	Differential Control Field	Stabilizing Field	Interim Field
Conductor Copper	N. C.	N. C.	#16 (.0508) AWG	N. C.	N. C.
Conductor Insulation	N. C.	N. C.	N. C.	N. C.	N. C.
Conductors in Parallel	N. C.	N. C.	N. C.	N. C.	N. C.
Turns per Coil	1750	N. C.	225	1100	N. C.
Feet of Wire per Coil	3240	8.4	439	2200	N. C.
Weight of Wire per Coil (lbs)	10-1/2	2-1/4	3-1/2	1-1/4	N. C.
Resistance per Coil	32.0	.00128	1.89	161.0	N. C.

Also: In the Motor Armature Winding Data, change Resistance of Armature from ".0235 ohms" to ".0275";  
In the Generator Stator Winding Data, change Resistance Between Terminals from ".191 ohms" to ".214";  
And in the Generator Rotor (field) Winding Data, change Resistance from "5.71 ohms" to "4.99 ohms".

Enclosure (2)

AER COMPLETION REPORT

Date:

From: Commanding Officer, USS

To: Commander Service Force, U.S. Pacific Fleet

Subj: COMSERVPAC AER Number \_\_\_\_\_; completion of

1. Subject AER was completed by \_\_\_\_\_  
\_\_\_\_\_ on \_\_\_\_\_

2. Allowance correction is/is not required. Required allowance  
data sheets are/are not appended hereto.

Enclosure (2)

DEPARTMENT OF THE NAVY

# Memorandum

DATE: 11-15-73

FROM : Code 270.12 *DLB*

TO : Code 1200

SUBJ : Evaluation of Kems Inc. Engineering Report on 30 KW MG Set Resistors.

Ref: (a) TM 0962-046-0010 - 30 KW MG Power Supply 230 VDC to 450V, 60 Hz.

Encl: (1) Kems, Engineering Report on 30 KW MG Set Resistor;  
evaluation of

1. Code 270.12 was requested to review Kems Inc. Engineering Report on the 30 KW MG Set Resistors on the USS QUAPAW (ATF 110) and make recommendations for corrective action.
2. The following comments are offered on the proposal of enclosure (1)
  - a. Make R11 = R12 = 75 ohm fixed as recommended in enclosure (1), but increase the wattage rating of R11 & R12 from 160W to 200W. The operating current through R11 & R12 would be approximately 87% of rated resistor current (200W resistors) in lieu of approximately 98% of rated resistor current (160W resistors).
  - b. Replace R13 with 20 ohm, adjustable resistor as recommended in enclosure (1) except increase the wattage to 60 watts. The higher wattage rating is necessary since the resistor wattage rating is applicable only when all resistance is in the circuit. The resistor wattage rating must be derated by approximately the same percentage as the reduction in actual resistance.

*Henry J. Fujisho*



 KEMS Inc.

PHONE 847-1195  
CITELEX 63227

239 PUUHALE ROAD  
HONOLULU, HAWAII 96819

USS QUAPAW (ATF-110)

ENGINEERING REPORT ON  
30KW M.G. SET RESISTORS

Jimmy C. H. Lim

ENCLOSURE (1)

NAVINE • COMMERCIAL • INDUSTRIAL  
DESIGN • SALES • MANUFACTURE • INSTALLATION • SERVICE

PROBLEM: Constant burning out of resistors  $R_{11}$ ,  $R_{12}$  in the panel of the 30KW M.G. set.

These resistors have incorrect value and power rating.

GIVEN KNOWNS:

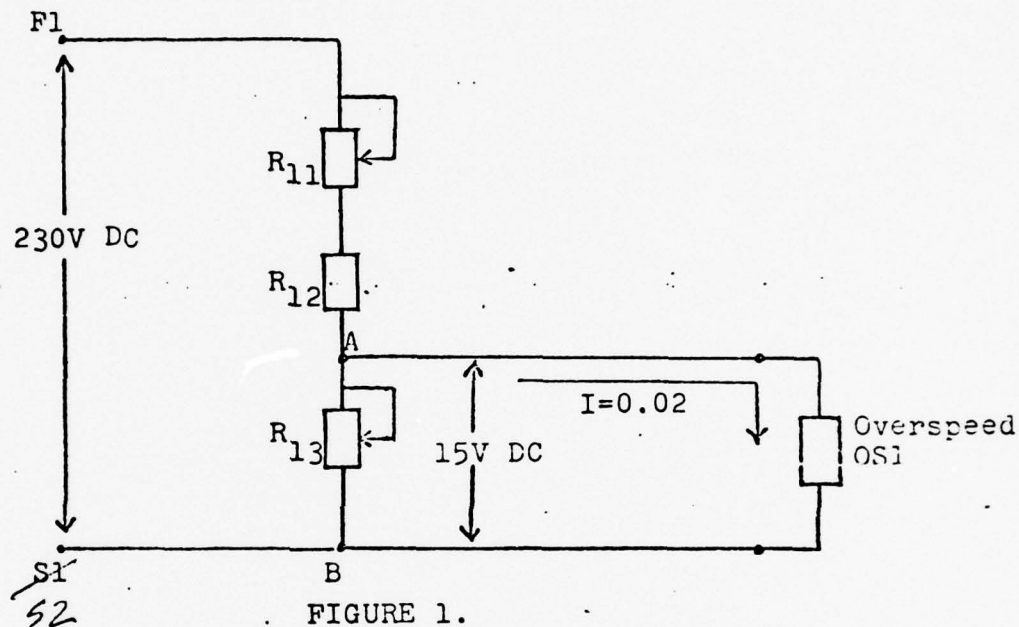


FIGURE 1.

$$\begin{aligned}
 V_{F1-S1} &= 230V \text{ DC} \\
 R_{12} &= 160W, 75 \text{ ohms fixed} \\
 R_{13} &= 25W, 10 \text{ ohms adjustable} \\
 R_{11} &= 160W, 75 \text{ ohms variable} \\
 V_{AB} &= 15V \text{ DC} \\
 I_{OS1} &= 0.02 \text{ amps (measured)}
 \end{aligned}$$

PROOF:

Step 1.

Solve for max  $I$  in  $R_{12}$

$$I_T = \sqrt{\frac{W}{R}} = \sqrt{\frac{160}{75}}$$

$$I_T = 1.46 \text{ amps maximum}$$

This is also I for  $R_{11}$ .

Step 2.

Prove that resistor  $R_{13}$  is out of range.

$$\text{Total } R = R_T = \frac{V_T}{I_T} = \frac{230}{1.46} = 157.53 \text{ ohms}$$

$$R_{13} = \frac{E_{13}}{I_{13}} = \frac{15}{(1.46 - 0.02)} = \frac{15}{1.44} \\ = 10.42 \text{ ohms}$$

This means that since OS1 circuit draws 0.02 amps at 15V DC, the required  $R_{13}$  is 10.42 ohms. However, the existing variable resistor  $R_{13}$  is only 10 ohms.

In order to get 15V DC across A-B, the current must be:

$$R_{13} = \frac{V_{AB}}{I_{13}}$$

$$I_{13} = \frac{V_{AB}}{R_{13}} = \frac{15}{10} = 1.5 \text{ amps}$$

which exceeds the max current (1.46 amps) that  $R_{12}$  can deliver.

Therefore, since  $R_{11}$  is not normally set at maximum of 75 ohms, more current flows and exceeds the rated current of  $R_{12}$  and  $R_{11}$ .

In other words:

- 1) If  $R_{11}$  and  $R_{12} = 75$  ohms each,  $R_{13}$  must be 10.42 ohms - which is impossible.
- 2) Ship's Force then reduces  $R_{11}$  so  $R_{13}$  has adjustment range; however, this allows more current to flow, thereby exceeding its ratings.

POSSIBLE SOLUTION:

- 1) Make  $R_{11} = R_{12} = 75$  ohms fixed, then
- 2) Make  $R_{13} = 20$  ohms adjustable so as to obtain the needed 15V DC.

Wattage of  $R_{13}$ :

$$I^2 = 2.07$$

$$W = I^2 R_{13} = 21.61W \text{ or } 25 \text{ watts}$$

THEREFORE,  $R_{13} = 20$  ohms at 25 watts.



- FACSIMILE -

KEM'S ELECTRIC MOTOR SERVICE  
Electric Motor Rewinding and Marine Specialists  
239 Puuhale Road / Honolulu, Hawaii 96819

September 30, 1968

Supervisor of Ship Building and Repair  
USN 14ND, Box 400  
FPO San Francisco, California 96610

Re: Modification of 30 KW/M/G Set to Operate on 115 Volt DC Input  
(a) Nav Ships Tech Manual 0962-046-0010

Dear Sir:

The following modifications was accomplished to change the MG set of reference (a) from 230 volt DC input to 115 volt DC input.

A. Motor Generator - Plan #03-0001-C of reference (a)

1. Changed brush size to: 2-1/4" x 1-5/8" x 3/4", carbon grade SA-45.
2. Changed brushholders to: 2502M series 5, 5/8" stud diameter, 1-11/16" center of stud to commutator, center of stud to back of brush box 1-3/8".
3. Paralleled shunt, series and commutator fields.
4. Rewound armature from wave to lap winding using same wire size.
5. Increased size of leads to size 2/0.
6. Re-stencilled nameplate for 115 volt.

B. Motor Controller - Plan #942-1-160M7

1. Replaced 230 Volt shunt coil part #9-1020-1 for NA52 contactor, with 115 Volt coil part #9-1020-A.
2. Replaced 230 Volt shunt coil part #9-1133-1 for N621 latching relay (CR) with 115 volt part #9-1133-2.
3. Replaced 230 volt shunt coil part #9-1076-15 for N867 timing relay (TR) with 115 volt coil part #9-1076-18.
4. Replaced 230 volt coil part #9-1788-2 for N914 contactor (IA) with 115 volt coil part #9-1785-1.
5. Replaced "RA" 3000 ohms resistor PC#5C with 750 ohm resistor Part #11003A4B-21.
6. Replaced 1500 ohm resistors PC#5D with 375 ohm Resistor part #11003H44B-26.
7. Replaced 2000 ohm resistor PC#5E with 500 ohm resistor part #11003A44B-20.
8. Reset N709 overload relay to operate between 400-600 amps.
9. Increased size of studs carrying motor current to 5/8" diameter and silver plated.
10. Increased size of bus bars carrying motor current to 1/4" x 1-1/2" and silver plated.
11. Paralleled starting resistors R2-R2 and R2-R3.
12. Increased carrying capacity of contacts carrying motor current by machining heels, installing silver inserts and silver plating the hole.
13. Re-stencilling nameplate for 115 volt in lieu of 230 volt.

Yours very truly,

KEMS, Inc.

Albert Martin, Assistant Mgr.

A-19/A-20

DEPARTMENT OF THE NAVY

# Memorandum

DATE: 2 November 1973

N-74

FROM SupShip 14ND, Code 1200

TO RINSYD Design Division, Code 244.1

SUBJ USS QUAPAW (ATF-110), Engineering Report on 30 KW M.G. Set Resistors;  
Evaluation of

Encl: (1) KEMS INC. Engineering Report on 30KW M.G. Set Resistors

1. Please review the enclosed Report and provide comments and recommendations  
for corrective action as necessary.

2. Return by: 8 November 1973

3. Refer to Job Order No. 20 620 0101-000 (IC#S2084) for funds required.

Copy to:

CSG-5 (Lcdr Walker) ✓

Code 12005

1213

1230

1310

*John Moniz*  
JOHN MONIZ

APPENDIX B  
ANALYSIS OF OVERSPEED CIRCUIT FAILURE  
ON 30 KW MG SET OF USS MATACO

(The following analysis is by Precise Power Systems Division, Thomaston, Conn. The report has been retyped verbatim to improve the legibility of the copy available to ARINC Research.)

- FACSIMILE -

PRECISE POWER SYSTEMS DIVISION  
401 Watertown Road  
Thomaston, Connecticut 06787  
(203) 283-5801 TWX 710-475-0537

31 October, 1973

TRIP REPORT - FT-0231

I. LOCATION

A. Yokosuka Naval Base, Yokosuka, Japan

1. SRF Facility

- a. CDR Somervill - Supt. Repair Facility
- b. Lt. Douglas - Design Section
- c. Mr. S. Ikeda - Shop Head, Shop 51

II. DATES OF SERVICE

A. 15 thru 21 October, 1973

III. EQUIPMENT

A. U.S.S. Mataco (AFT-86)

1. 30 KW MG Sets, 115 VDC to 450 VAC, 3 Phase, 60 Hertz

- a. MG Set #1 - Serial Number 12L5152
- b. MG Set #2 - Serial Number 13L5152

B. Ships Force

- 1. Lt. J. P. Smith - CO
- 2. CWO Cowles - Engineer
- 3. EM1 - Doug Bolen
- 4. EM2 - Gene Turnen

IV. PROBLEMS ENCOUNTERED

A. MG Set #2

- 1. Overspeed PC Card (A6) inoperative. Foil burned from board, improper components installed, cold solder connections, etc.
- 2. MG Set trips shut down due to actuation of overspeed trip circuit SCR as various DC equipment is placed on ships load. Problem is intermittent and ship cannot keep 60 Hertz MG Sets operating unless Overspeed PC Card is removed from the Control Cabinet.



IV. PROBLEMS ENCOUNTERED - Continued

B. MG Set #1

1. Overspeed PC Card (A6) inoperative. Improper components installed, cold solder connections, etc.
2. MG Set shuts down when ship transfers from Shore D.C. Power to Ships D.C. Power, and vice versa. MG Set cannot be restarted for approximately ten minutes, then will operate without difficulty until transfer of D.C. power is repeated.

V. WORK ACCOMPLISHED

A. MG Set #2

1. Overspeed PC Card (A6) returned to original configuration and components. Missing foil replaced by using insulated bus wire. Overspeed timing calibrated to 18% (70 Hertz) overspeed trip.
2. Overspeed trip SCR (CR7) appeared to be tripping due to DV/DT, although on a very infrequent basis. With gate lead disconnected the SCR could be made to turn on occasionally by actuation of the Start switch. The CR7 SCR, a TRW 2N687, was replaced with a higher voltage IR device, our plant part J94-0189, and no further DV/DT tripping was observed.
3. The problem of this MG Set shutting down as additional ships D.C. load was applied to the ships or shore D.C. power was traced to noise pick-up coming into the Overspeed P.C. Card (A6) via the magnetic pick-up harness from the MG Set to the Control Cabinet. The noise, high in frequency and of an amplitude greater than that of the magnetic pick-up pulse, biased the overspeed trip circuit and caused CR7 to turn on shutting down the M.G. Set. By activating various warning horns, and especially one particular vent fan, sufficient noise could be introduced to trip the overspeed circuit and shut down the MG Set, even though actual overspeed had not occurred. With the vent fan on the MG Set could not be restarted unless the overspeed trip circuit was defeated. This problem was resolved by removing the magnetic pick-up shield, from the MG Set housing ground and re-connecting the Control Cabinet end of this shield to D.C. reference in the control system. With the shield tied in this configuration, no noise was observed on the magnetic pick-up

V. WORK ACCOMPLISHED - Continued

harness as various ships load was applied to the D. C. supply. Activation of the vent fan, especially, ceased to have any effect on the quality of the signal being received from the pick-up.

B. MG Set #1

1. Overspeed PC Card (A6) returned to original configuration and components. Overspeed timing calibrated to 18% (70 Hertz) overspeed trip.
2. DV/DT breakdown of CR7 (a General Electric 2N687) was not observed on this unit. However, a like SCR (J94-0189) has been set to the USS Mataco for installation in the overspeed circuit.
3. In view of the problem observed with MG Set #2 concerning the noise pick-up from the grounded shield wire, the magnetic pick-up shield was disconnected from the motor housing and tied to D. C. reference at the Control Cabinet. This prevented any noise from affecting the overspeed circuit by way of the magnetic pick-up harness, but a constant D. C. potential was observed at the pick-up input to the Control Cabinet when the ship transferred from shore power D. C. to ships power D. C. The constant potential, approximately 7.5 VDC, slowly decayed to 0 volts (in approximately 10 minutes) and during this period the MG Set could not be restarted without defeating the overspeed trip circuit. This problem was traced to a high resistance ground in the magnetic pick-up. The faulty pick-up, due to the positive side of the D. C. Shore Power being grounded (a fault determined after considerable isolation and investigation), charged up to a D. C. potential when the Ship was being supplied by shore power. When the ship transferred to internal power the +120 VDC was no longer grounded and the magnetic pick-up, acting like a capacitor, discharged through the overspeed circuit preventing activation of the MG Set for approximately 10 minutes. A replacement pick-up was not available at Yokosuka and the problem was temporarily corrected by isolating the magnetic pick-up bracket from the motor housing using insulated washers and inserts. A replacement pick-up (our part number N01-0001) was sent to the ship on 10-30-73. Installation of this part will permanently correct the problem.

VI. RECOMMENDATIONS

- A. The following changes were made to both Control Cabinets on the USS Mataco, and these changes are recommended for all ships using this equipment:
1. Remove magnetic pick-up shield from motor housing ground.
    - a. Cut shield flush with harness insulation at motor end. Secure to harness with insulated tape.
  2. Connect Control Cabinet end of magnetic pick-up shield to TB9-6 (at bottom of cabinet).
  3. Replace SCR CR7 with a 400 volt device (International Rectifier 22RC40, or equivalent).
  4. Refer to enclosures (1) and (2):
    - a. On the back side of PC Card A6 (Overspeed Monitor) cut pin L foil as shown and insert a 1N751 Zener Diode in series with the cut foil. Position diode as shown on enclosures. This diode will insure that the SCR gate voltage remains at zero until an overspeed condition actually occurs.

VII. TIME VERIFICATION

A. Service Time

1. 15 thru 21 October (7 days) - 8 hours per day.

B. Travel Time

1. Travel to: 13 and 14 October (2 days) - 8 hours per day.
2. Travel from: 22 and 23 October (2 days) - 8 hours per day.

VIII. GENERAL

- A. Both MG Sets and controls appeared to be regulating properly when I arrived, although several PC Cards had been reworked with substitute components. All of these cards were reverted to their original configuration prior to start of testing.

- FACSIMILE -

VIII. GENERAL - Continued

- B. 60 Hertz transformers and relays have been added to each Control Cabinet for some purpose relating to a parallel lockout circuit. These components were added with no regard for the possibility of 60 Hertz pick-up becoming induced into the Control Cabinet harness. According to the ship, these parts were installed in the system at San Diego when the MG Sets were put on the ATF-86.
- C. SRF Yokosuka really dug into their crystal ball to support me on this trip. A special thanks to Commander Somervill for his excellent cooperation and assistance, and to Mr. S. Ikeda, Shop 51 Head, for always managing to locate the equipment, parts and knowledge that eventually led to the resolution of the problems encountered.
- D. In concluding this report I personally commend Lt. Smith and the entire ships force of the USS Mataco for the outstanding support and assistance that was given to me during my visit to the ship. With complete disregard for the time of day, or the sometimes substantial manpower that was required to conduct certain tests, this ship supported me in an overwhelming fashion. The problems encountered took a team effort to correct and, in my opinion, one member of that team, EM1 Doug Bolen, is one helluva sailor.

- End Report -

TECH SYSTEMS CORP.  
PRECISE POWER SYSTEMS DIV.

R. Minicucci  
Field Support Engineer

Enclosure: (1) Overspeed Monitor, Drawing 30500121-2  
(2) Printed Circuit Board, Drawing 31500121

Distribution List:

Naval Ship Engineering Center  
Code 6158C  
Philadelphia Division - O. Reed

SRF Facility, Yokosuka - Commander Somervill

USS Mataco (ATF-86) - Commanding Officer



APPENDIX C  
ANALYSIS OF FAILURE OF  
OVERSPEED CIRCUIT ON 30 KW MG SET

(The following analysis is by ARINC Research Corporation.)

## OVERSPEED CIRCUIT ANALYSIS

The overspeed circuit board from the MG set identified by Technical Manual NAVSHIPS 0962-046-0010 was analyzed in detail. The circuit schematic is shown in Figure C-1.

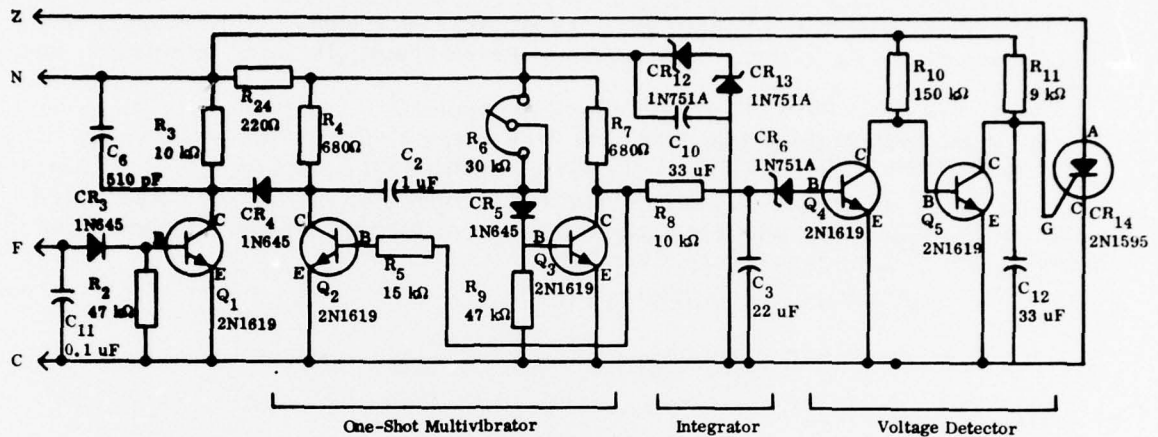


Figure C-1. Overspeed Circuit of 30 kW Motor Generator Set\*

### C.1 TEMPERATURE SENSITIVITY TESTING

Laboratory tests were conducted to determine the circuit's operational condition. The circuit was placed in an environmental test chamber at 25°C and the temperature gradually increased to 50°C. A pulse generator was used as the input signal, and the pulse frequency was increased until the SCR fired. The trigger frequency was recorded as follows:

Temperature, °C	Trigger Frequency, Hz
25	33
30	32
35	31
40	30
45	29
50	28

\*Figure C-1 reflects a correction that should be made in the circuit given in TM 0962-046-0010. Capacitor C12 should be located between Q5 and reference, as shown above; and not between Q4 and reference, as in the TM figure.

The above data indicates a frequency change of 5 Hz for the 25°C variation, which explains why the overspeed circuit actuated at high temperatures. Since nominal frequency is 30 Hz (1800 rpm ÷ 60 = 30 rps), the overspeed circuit sensed an overspeed condition when temperatures exceeded 40°C and therefore actuated the relay to turn off the motor.

## C.2 CIRCUIT ANALYSIS

Detailed circuit analysis was conducted to determine possible modifications that can be made to reduce the temperature sensitivity. For analytical purposes, the circuit was divided into three basic parts – one shot multivibrator, integrator, and voltage detector.

### C.2.1 One-Shot Multivibrator

Since the integrator output is a function of input pulsewidth, the output pulsewidth of the multivibrator is the critical parameter for that circuit element. For the multivibrator, the pulsewidth is given by:

$$t = -RC \ln \frac{V_{be} + V_d - V_{cc}}{V_{be} + V_d - 2V_{cc}} \quad (1)$$

where

$$R = R_6 = (30 \text{ k}\Omega)$$

$$C = C_2$$

$$V_{be} = \text{base-emitter voltage of } Q_3$$

$$V_d = \text{forward diode voltage of CR}_5$$

$$V_{cc} = \text{collector supply voltage}$$

Evaluation of the partial derivatives of equation (1) yields the following percent change in pulsewidth for a 10% change in each of the multivibrator parameters. (The 10% change in these parameters simulates the changes due to temperature effects.)

<u>Parameter</u>	<u>Change in PW for 10% Param. Change</u>
$V_{be}$	+0.48%
$V_d$	+0.48%
$V_{cc}$	+1.07%
$R_6$	+10.0%
$C_2$	+10.0%

It can be seen that variations in  $R_6$  and  $C_2$  have the greatest influence on pulsewidth. This analytical observation was substantiated in the laboratory. The multivibrator circuit was placed in an oven, with components  $R_6$  and  $C_2$  hooked up externally to the oven. As the oven temperature was increased from 25° to 50° C, a trigger frequency variation of 3 Hz was observed, as opposed to 5 Hz when the subject components were in the oven. This observed change in trigger frequency variation is within what would be expected for the temperature coefficients of  $C_2$  and  $R_6$ .

During the same experiment, other components were removed from the oven and the circuit tested as above. No significant changes in trigger frequency variation were observed.

Based on these findings, the replacement of  $R_6$  and  $C_2$  with components having lower temperature coefficients is recommended. (See Section C.3.)

### C.2.2 Integrator

The output voltage of the integrator has the following waveform:



Equations for the upper and lower voltage levels ( $V_1$  and  $V_2$ , respectively) were derived in terms of the input signal and the values of  $C_3$  and  $R_8$ . These equations are:

$$V_2 = \frac{V_{cc}(1 - e^{-t_1/RC})}{(e^{t_2/RC} - e^{t_1/RC})}, t_1 \neq t_2 \quad (2)$$

$$V_1 = V_2 e^{t_2/RC} \quad (3)$$

where:

$$R = R_8$$

$$C = C_3$$

$$t_1 = \text{one-shot pulsewidth}$$

$$t_2 = \text{one-shot period minus } t_1$$



The change in output voltage of the integrator resulting from a 10% change in either R<sub>8</sub> or C<sub>10</sub> was calculated as 0.67%, showing that circuit operation has only minor sensitivity to changes in these component values.

### C.2.3 Voltage Detector

The voltage detector was analyzed by first examining operation of Q<sub>4</sub> and Q<sub>5</sub>. Q<sub>5</sub> (a 2N1613) has a maximum base drive of

$$I_b = \frac{15V}{150 \text{ k}\Omega} = 0.1 \text{ mA} \quad (4)$$

Minimum beta for this transistor at 25°C is 40 at I<sub>c</sub> = 5 mA. The resulting collector current with maximum I<sub>b</sub> and minimum beta would be:

$$I_c = (40)(0.1 \times 10^{-3}) = 4 \text{ mA} \quad (5)$$

The collector current required for complete turn-on is:

$$I_c = \frac{V_{cc}}{R_c} = \frac{15V}{3 \text{ k}\Omega} = 5 \text{ mA} \quad (6)$$

It is seen, therefore, that there is insufficient base drive to saturate Q<sub>5</sub>. Further, R<sub>10</sub> (150 kΩ), the collector resistor for Q<sub>4</sub>, reflects a minimum base current for Q<sub>4</sub> saturation that is well below the zener diode test current. (The zener is connected in series with the base of Q<sub>4</sub>.) Saturation of Q<sub>4</sub> at low base current and therefore low zener current may result in the zener starting to switch well below the knee of its voltage characteristic curve. This is undesirable from an operational viewpoint because the circuit is very sensitive to transients and thus to false triggering.

To increase the base drive needed to saturate Q<sub>5</sub>, and to bias the zener to operate at a current level close to its knee, it is recommended that R<sub>10</sub> (150 kΩ) be replaced with a resistor of lower value, say 1 kΩ.

The above analytical results were observed in the laboratory. The output of the integrator (R<sub>8</sub> and C<sub>3</sub>) was measured at the point of turnon of the voltage level detector and subsequent firing of the SCR. This level was 2.25 volts. This value for triggering indicates that the 5.1 volt zener diode (CR<sub>6</sub>) is operating below the knee of its characteristic, and therefore the zener effect is not being utilized to achieve an abrupt turnon of transistor Q<sub>4</sub> at the required voltage level. This effect is due to the present circuit design – abrupt voltage detection cannot be achieved in the present configuration. A simple modification, such as shown in Figure C-2, may be used to provide a stable voltage detector and thus avoid all of the above problems. The modification illustrated in Figure C-2 would require circuit board changes and therefore may not be easy to implement. An alternative modification – simpler, but not quite

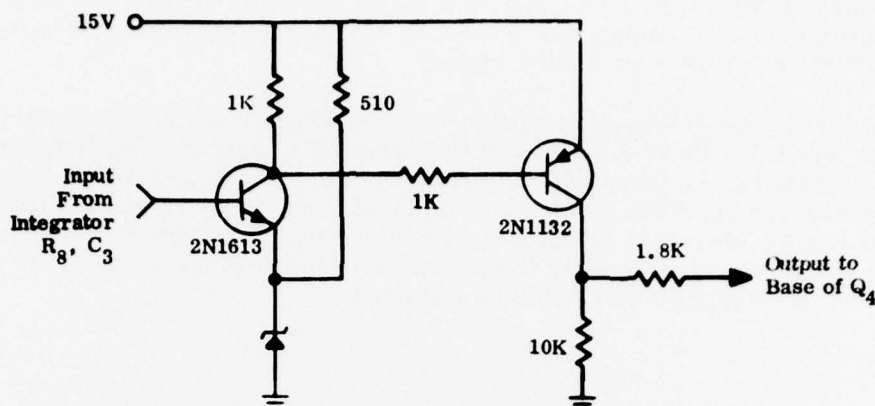


Figure C-2. Recommended Modification to Voltage Detector

as effective – would be to substitute a 1 k $\Omega$  resistor for the present 150 k $\Omega$  resistor at R<sub>10</sub>, as described previously. The alternative modification would not provide as stable a circuit as the initially suggested one, but would reduce the reference problem.

### C.3 RECOMMENDATIONS

To correct the deficiencies noted above, the minimum modifications needed to the overspeed circuit are:

- a. Replace R<sub>6</sub> and C<sub>2</sub> of the one-shot multivibrator with temperature-stable devices. Possible device substitutions are:

R<sub>6</sub> – RT12C2L203, RT11C2L203, or PT22C2L203 (MIL-R-27208 wirewound potentiometers)

C<sub>2</sub> – Metalized polycarbonate, TRW type X463UW (1 uF, 50V, 0.312" diam., 11/16" length)

These devices have temperature coefficients at least twice as good as those of the present devices.

The recommended substitution for C<sub>2</sub> is not the same size as the present device; therefore, a circuit board modification may be necessary to accommodate the change.

- b. Replace the 150 k $\Omega$  collector resistor, R<sub>10</sub>, with a 1 k $\Omega$  resistor RC20GF102K.
- c. Adjust the threshold from the present 10% to 15% over nominal frequency.

A "complete" fix of the overspeed circuit problem would be to accomplish the above modifications and to add the circuit shown in Figure C-2. Addition of that circuit would require a board redesign, but would result (in conjunction with the above-recommended modifications) in a frequency stability, confirmed in laboratory testing, of approximately 2 Hz over a 25°C range.

If only items a through c, above, are accomplished, the frequency stability would be about 3.5 Hz to 4.0 Hz over the same 25°C range. This frequency change can be tolerated if the threshold is adjusted to 115% of its nominal 30 Hz, or 34.5 Hz. With the adjustment of the threshold to 115% of its nominal value, the frequency stability can be tolerated; therefore, recommendations a through c should be adequate for this situation. If, however, the set is subjected to larger and higher temperature variations, a "complete" fix would be required.

APPENDIX D

ANALYSIS OF OVERSPEED RELAY FAILURE  
ON 30 KW MG SET OF USS SAFEGUARD

(The following analysis is by the Planning Department, Pearl Harbor Naval Shipyard.)



SAFEGUARD ARS-25

From Design Division

R (a) N/S 0961-040-4010 TM for 30 KW MG and Associated Control Equipment

1. The USS SAFEGUARD (ARS 25) reported premature actuation of the overspeed relay on the #2 30 KW MG set following installation and test of both units by the contractor. Both units were new units furnished by the Government.
2. A high noise level was noted when an oscilloscope was placed at the input of the overspeed monitor of MG #2. Very little noise was noted on #1. The noise took the form of random spikes, some larger than the pulse output of the magnetic pickup.
3. The magnetic pickup was disconnected from #2 and a pulse generator was substituted. The input to the overspeed monitor was observed on the oscilloscope and an overspeed condition simulated by increasing the frequency of the pulse generator. Shutdown of MG #2 was noted at a pulse generator frequency corresponding to about 2070 RPM (115% of the rated 1800 RPM). The overspeed monitor of MG #2 was considered to be operating satisfactorily.

REV	PG	DESCRIPTION	BY	APPD	DATE
REVISIONS					
Lead P & E	1200	1200	4		
Code	---	270.1	1		
Lead Shop	---	270.11	1		
W.B. No.	215	320	1		
J.O. No.	20 787 0204	277	1		
WITNESSED ON		220	1		
USS	SAFEGUARD	204.22	1		
Ship Rep		246.12	1		
Prod Rep					
Div Rep					
		CODE OR SHOP	No.	CODE OR SHOP	No.
		CODE OR SHOP	No.	CODE OR SHOP	No.
		CODE OR SHOP	No.	OTHER	No.
		ARS 25			1
		SHIP			DR
		DISTRIBUTION			APPLICABLE SHIPS
AUTHORITY		Subject 30 KW MG SETS OVERSPEED; INVEST & RPR			
PLANNING OFFICER					
SECURITY CLASSIFICATION		DESIGN DIVISION PLANNING DEPARTMENT MEMORANDUM			
		Prepared By C. PANG			
		Code 270.11 Tel: 474-5132			
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		By: J. Mura			
		Date: 5084			
		Activity: 270.11			
		Approved By:			
		Date:			
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		Approved By: J. Mura			
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		Approved By: J. Mura			
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		Sheet 1 Of 2			
		ID #			
		DM-ARS25-300-4618947			
		REV Change #			

4. The #2 MG was disassembled to permit access to the magnetic pickup. It was noted that the magnetic pickup of #2 was not centered over the magnetic contact. Also the pickup of #2 was farther from the contact than in the #1 MG. Both adjustments were made and the output of the magnetic pickup at the #2 MG was monitored. Considerable improvement was noted.
5. The two wires which connected the magnetic pickup to the overspeed monitor were checked and found free of open circuits and grounds. However, it was noted that the wires in the #2 MG were unshielded wires from a four wire cable. The other two wires fed SCR controlled current to the generator field. In contrast connections between the magnetic pickup and the overspeed monitor on MG #1 were made using two shielded wires from a separate cable.
6. It was also noted that the noise was mostly to one side of zero while the magnetic pickup output was of equal amplitude about zero. To take advantage of this the leads to the overspeed monitor were hooked up such that a series diode would block most of the noise.
7. MG #1 overspeed monitor trip point was checked and found to be set too low. The unit was reset to trip at about 2070 RPM. #2 overspeed monitor was rechecked and found still satisfactory.
8. It is felt that #2 MG shut down prematurely because of the noise spikes on the input to the overspeed monitor. The noise was caused in part by incorrect magnetic pickup placement, and in part by the use of unshielded wire in a cable with other wires carrying noise inducing current. The magnetic pickup was adjusted but the induced noise could not be totally eliminated. The change in wiring to block some of the noise with a diode should allow normal operation of #2 MG.
9. A total of about 16 man-hours were used in preliminary analysis, troubleshooting and repair, and report writing.

SECURITY CLASSIFICATION

DESIGN DIVISION  
**PLANNING DEPARTMENT**  
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REV Change #

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U. S. Navy

U. S. Navy

Naval Research Corp.  
451 Five Road  
Bethesda, Maryland 20814

(A) (S)

Naval Research Corp.  
451 Five Road  
Bethesda, Maryland 20814

(A) (S)

Naval Research Corp.  
451 Five Road  
Bethesda, Maryland 20814

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the 2.5 kW diesel generator set.

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